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AIR & SPACE

Smithsonian

SEPTEMBER 1999

XB-70
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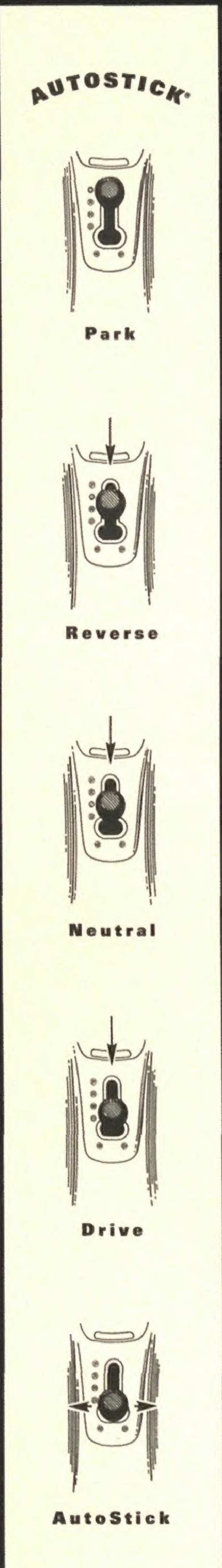

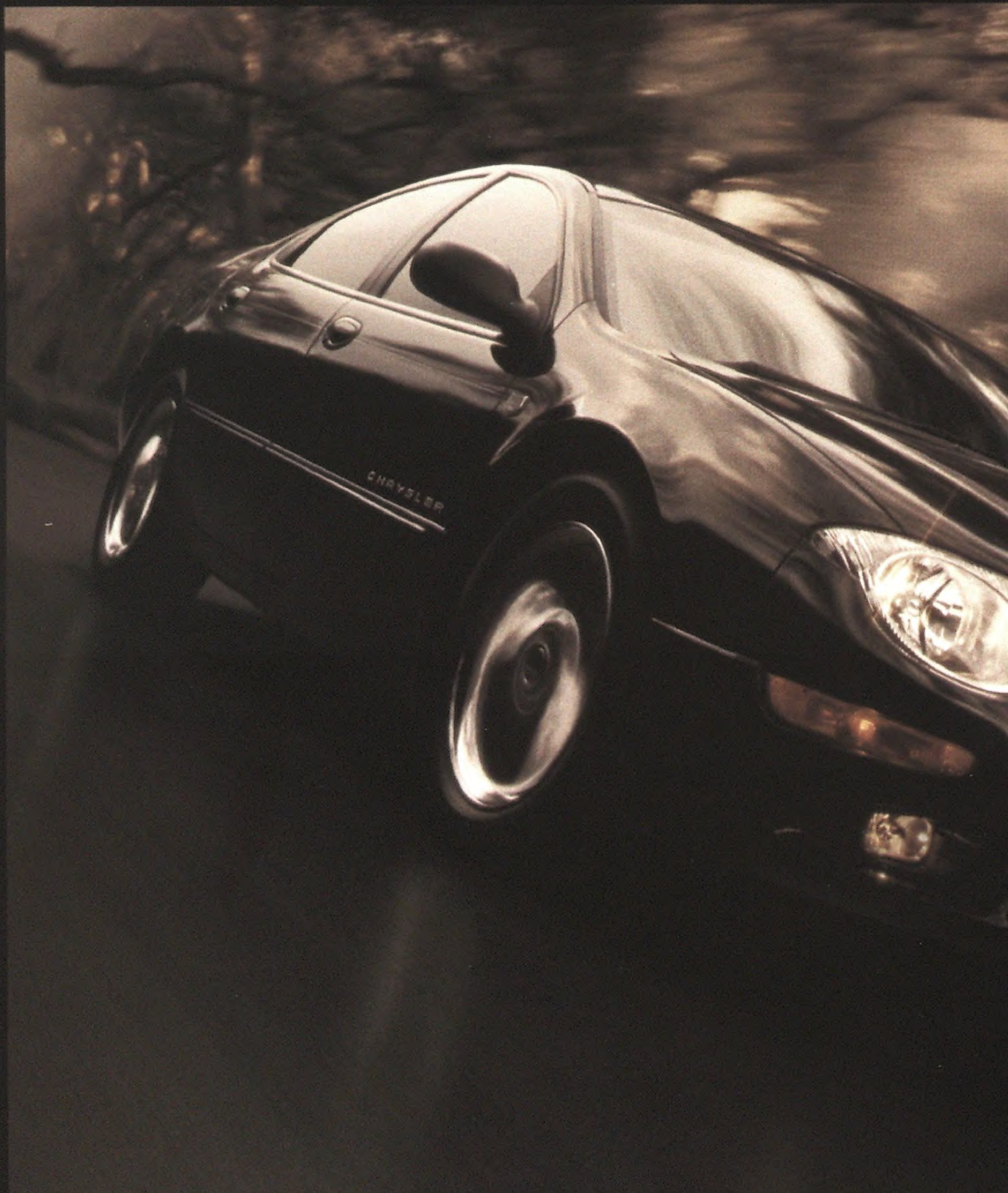

In 1956, the Chrysler 300B, equipped with a 354-cubic inch Hemi engine, generated 355 horsepower and won Daytona's Flying Mile top speed event.

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engine block.

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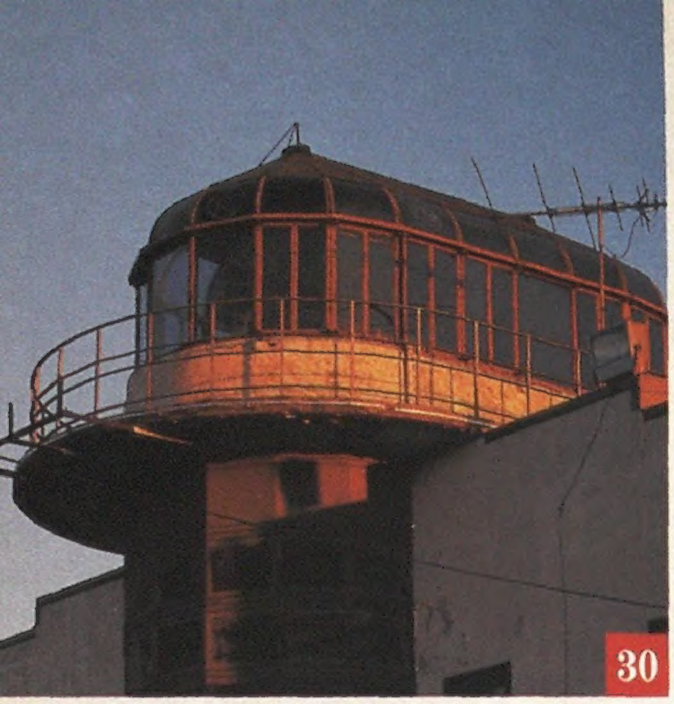

AIR&SPACE

Smithsonian

August/September 1999
Volume 14 • Number 3

FEATURES

Cover: Six General Electric YJ93-3 engines push the 500,000-pound Valkyrie skyward in this USAF Flight Test Center photograph.

DEPARTMENTS

Page 8

Donald D. Engen, 1924-1999

It saddens us to have to report that one of our airmen is missing. As we went to press, Donald D. Engen, director of the National Air and Space Museum since 1996, lost his life in a glider accident on July 13, 1999. He loved soaring, and it is simply impossible to avoid the thought that he was pursuing his life's passion at the time of his death.

But that would ignore his far greater passion, which was a lifelong dedication to safety in all aspects of aviation. That higher purpose was his obsession during his career in the United States Navy, where he rose to the rank of vice admiral. Later, when he was appointed to head the Federal Aviation Administration by President Ronald Reagan, he pushed for safer flight operations, airplanes, and pilots. There are those who give a lot of lip service to the cause of safety, but Engen took it personally.

Yet Engen's philosophy toward safety was more complicated than simple zealotry. As a test pilot, he embraced the idea that manned flight is advanced only through the acceptance of risk, and as a pioneer in the adoption of turbojet-powered aircraft for naval carrier operations, he frequently flew beyond the known bounds of safety. It was the kind of flying that moves the envelope, expands it, and re-defines what is safe. During those years, he watched as friends tested the outer limits and found disaster. In his memoir, *Wings and Warriors: My Life as a Naval Aviator*, he shared his most intimate thoughts about both successes and failures. He learned from both.

Engen was initially tapped to advise on the selection of a new director for the Museum when a search was begun in 1995, but it wasn't long before there was talk of his taking on the role himself, an idea he welcomed. But he had to wait for the protracted process to run its course, and when he finally was named to the post, he met the small gathering of reporters in a Museum dining room with the looming dome of the Capitol behind him through a window wall. He could have used the moment to personal advantage, but he didn't. The Museum had been wracked with difficulties, and he would face enormous challenges.

Reporters baited him with questions about the problems, but he wouldn't bite,

CAROLYN RUSSO

instead declaring it a "new day." He always preferred to emphasize the positive.

And so he set to work, with his personal goal clearly set: completion of funding for a long-planned Museum center at Dulles International Airport. He pursued it with the same single-mindedness that was characteristic of his entire career. There were days when he seemed to be the only optimist in the building, but his one-man version of *esprit de corps* gradually infused the entire staff with a renewed sense of purpose.

He learned leadership in the Navy and adopted the value system to which military officers swear allegiance: It is a system bound up in the word "honor." He believed in the idea that an individual can spend an entire life in service without focusing on one's own ambitions. In a peculiar way, he knew the ways of Washington like an insider, yet he never was one. Perhaps that was because he simply found it discomfiting to say what people wanted to hear if he knew the truth lay elsewhere. You could take his word and his handshake to the bank.

And so the Museum has lost a leader and a friend. As have you.

In this space, Engen told you what was on his mind, be it his fundraising pursuits or his worries about the state of aviation. Whatever he wrote, he always wrote from the heart.

Tailwinds, sir.

—The Editors

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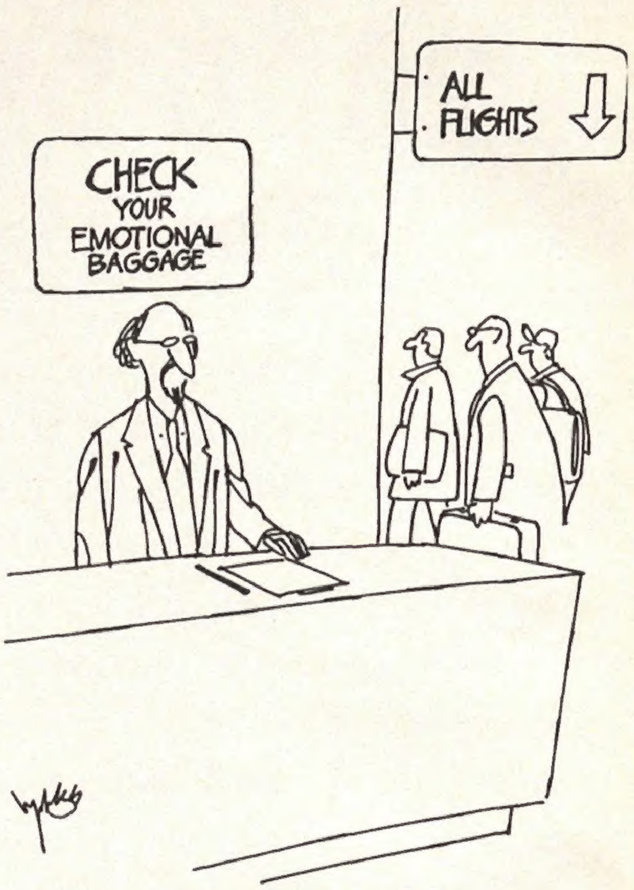
LETTERS

Not Everyone Can—or Should—Fly

Having read Don Engen's "You Can Fly" (Viewport, June/July 1999), I have to say that the day 439 people out of 440 learn how to fly is the day I give up aviation. There are many good reasons why only one in 440 people have a pilot's license—and the cost of lessons is not always one of them. Not everyone has a reason to rent a plane to go somewhere, and not everyone can keep up good pilot skills. If the distance is great enough, I'd rather take a commercial flight and let a professional pilot take care of the details. The sky isn't meant for the "average" pilot. Statistics show that flying remains the safest form of mass transportation. Let's not ruin aviation's safety record by removing traffic congestion from the ground and putting it in the air.

—Harry Martin
Thousand Oaks, California



Where should I start? Maybe with the cost of flying. Renting an aircraft averages $50 per hour (for a two-seater Piper). I could rent a car for the entire day for $23. That free or low-cost first flight is a nice tease for the first-time fliers, but they soon realize that it's an expensive venture. The Federal Aviation Administration requires a minimum of 40 hours (35 for an FAA-approved school), but most people need more. It usually costs about $5,000 for the average person to attain a pilot's license.

—Ed Howard
Sloatsburg, New York

There are over 30,000 of us ultralight aircraft pilots who excel at flying safely and are banned from most county airports—southern California is a case in point. Disliked by other pilots, scorned by many, we keep flying anyway because we love it. The cost to become rated as a private pilot is more than my complete investment in ultralight aviation—and I own my plane!

—Bernie Tusler
Chula Vista, California

This editorial brought to mind a project I was involved in 40 years ago. Robert Gross, the founder and CEO of Lockheed, had charged Irv Culver with developing an aircraft that "anyone could easily and safely fly" as a supplement to the automobile. The airplane was rejected—probably because it has the least control power when you needed it most, during takeoff and landing, and because most people live in cities where land for runways is very expensive. Culver thought that the helicopter could be developed into an easy-to-fly machine. A half-dozen of us designed a testbed to first flight in about 100 days, and then designed five different rotors in 18 months before we had one worth demonstrating. The aircraft was, indeed, easy to fly. One day, after the pilot had gone home, a mechanic—with no instruction—flew it back to base camp. After leaving Lockheed, I built and flew a rotorcraft based on the latest design that we had tested in a wind tunnel and found it to be easier to fly than any lightplane I had flown. Unfortunately, Gross died before we completed the development, and his vision of an air age died with him.

—Tom Hanson
Newhall, California

Engen's editorial is a commendable plea for more Americans to become pilots. But his pitch is a tad overstated. He writes: "Once earned, a pilot's license is all you need to get into the air." Maybe, for openers. Then there are all the follow-up requirements: a physical exam every two years, the biennial flight review, the need for up-to-date charts, etc. Then, "you can always rent the airplane." I doubt there is a single Fixed Base Operator who, like the Avis clerk, will just hand you the keys. First there's the check-out of a few times around the patch, typically with a certified flight instructor. Certainly, we need more recruits in the flying fraternity. But membership makes many demands, both statutorily and realistically. The supplicant should be fully aware of them.

—Lt. Col. Walter Albrecht
U.S. Air Force (ret.)
New York, New York

Mistaken Identity

Having flown many hours in old Douglas aircraft, I noticed that a photograph of one was misidentified in "Lifeline" (Apr./May 1999). The picture on page 55 does not show a DC-4 but rather a C-118, the military version of the DC-6. A couple of dead giveaways: the paddle blade props and prop nose spinners. The DC-4 and its military version, the C-54, had neither.

—Russell D. LaPray
Las Vegas, Nevada

Editors' reply: The National Air and Space Museum archivists say that you and others who wrote similar letters are probably correct. However, we also heard from readers who thought the aircraft was a DC-7. We welcome further debate.

Prowlers in the Attic

In "Home Vrrroom" (Soundings, June/July 1999) I came across this passage: "Whatever it is—busted altimeter, dead automatic direction finder, discarded EA-6B, flattened Mae West, or permanently stuck mike—he'll take it gladly." Hmmm. EA-6B...EA-6B.... Now I know I saw that old Prowler up here somewhere. Nope, that's my whiz wheel. Let me check this trunk over here.... Now where did that thing go? It's up here somewhere...

—Ken Badziak
Currently deployed in Italy

Editors' reply: D'oh! *We meant E6-B, the old flight planning calculator. But if you do find an EA-6B in your attic, Clayton Carkin will gladly find a home for it at Freeport, Maine Middle School.*

Roll Model

Despite the focus of "One Helluva Roar" (Apr./May 1999), the Acrojets were not the first U.S. Air Force aerobatic unit of four or more aircraft. That honor goes to the Fourth Fighter Group Demonstration Team. We were assigned to Andrews Air Force Base in Maryland in March 1947. After our performance in Cleveland in September 1948, four-ship jet aerobatic teams proliferated in the Fourth Group. The following spring, the Fourth Fighter Wing was transferred to Langley Air Force Base in Virginia and equipped with F-86 Sabre jets. The Fourth Group team was one of the first—if not the first—to fly the F-86.

—L.E. McCarthy
Camarillo, California

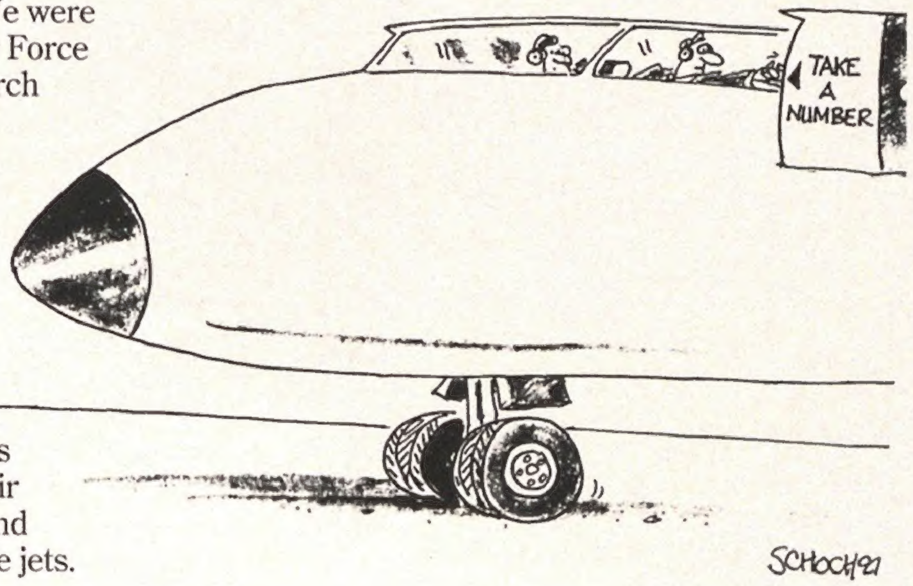
High Society Hijinks

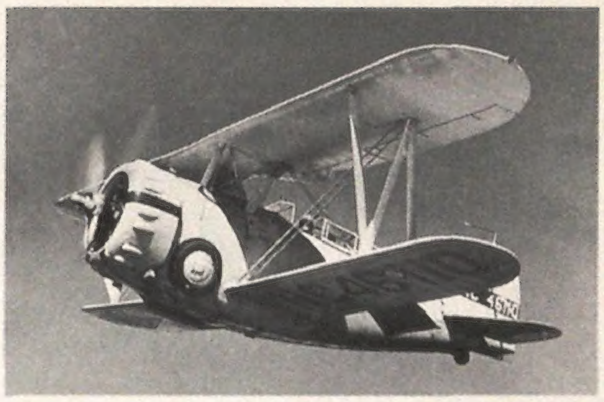
Roy Grumman was my father, and he let me take flying lessons in the late 1930s, when I was a teenager ("High Society," Feb./Mar. 1999). In 1940 my family moved next to the Phillips family in Plandome, and though it never occurred to me at the time, I guess that Ellis Phillips (my future husband) got the idea from me to take flying lessons. Because it was a very popular thing to do, Roosevelt Field and the Aviation Country Club of Long Island were jumping with flying students. We often had to make appointments for lessons at 7 a.m.

Flying that early in the morning was always nice—not much wind and then of course we had breakfast at the clubhouse afterward. All the Grumman test pilots, when they had time, would come over from Bethpage to give flying lessons. We both took lessons from Bud and Betty Gillies, Jackie Cochran, Hank Kurt, Hank Schiebel, and others. The F-24 had a stick, and Ellis thought it was pretty racy that Betty would pull her skirt up above her knees so she could manage that control.

The article referred to runways, but there were none. It was a grass field and we landed and took off anywhere. When I was taking lessons from Hank Schiebel he was not happy about my landings. I was coming in too high and landing too far down on the field. One day he set his hat, a felt fedora, on the grass and told me to land on line with the hat. Well, it was dumb luck, but I not only landed exactly on line with the hat, but I landed on the hat—and tossed it several feet in the air. Hank was quite impressed, and for weeks kept wearing that beat-up headpiece with the grass stains, telling tales about his teenage student and her landings.

—Marion Grumman Phillips
Medfield, Massachusetts





"High Society" mentions Roy Grumman's new G32A. My boss at the time, Gene Patterson, owned the airplane in the late 1940s (above). He told me that he had bought it from the second owner, a pilot in Virginia who quickly found out that it was more than he could handle. Gene took me for a ride that I will never forget: It was the first time I was ever in a "tail stand." Gene sold the G32A to another local pilot, Chet Hogshead, and eventually it left the Chattanooga area. Later, it was sold to the Champlin Fighter Museum in Mesa, Arizona. It was to be delivered there after the 1971 fly-in at Oshkosh, but Gene Chase, the delivery pilot, had a carburetor fire shortly after takeoff and he and his passenger bailed out. The Texas Airplane Factory in Fort Worth, Texas, bought the remains and used some original parts in a reconstruction, which is now in the Cinema Air collection in Carlsbad, California.

—Dan N. Williams
Signal Mountain, Tennessee

Mania Minus Two

In reviewing the list of Mustangs that attended the Gathering of Mustangs and Legends ("Mustang Mania," June/July 1999), we discovered that someone here had miscounted. The correct number of Mustangs in attendance was 65, not 67.

—Angela West
Mustang OPS
Kissimmee, Florida

Asteroid, Not Meteorite

"Night of the Shooting Stars" (June/July 1999) states that a leading theory on the extinction of the dinosaurs is that it was caused by a meteorite. Meteorites don't grow that big. An asteroid, some six to seven miles in diameter, is believed to be responsible.

—Saunders B. Kramer
Montgomery Village, Maryland

Arms Deal

I enjoyed Tom Harpole's "Strong Arm" essay about the Canadarm in the July

AIR & SPACE CONTEST

UNIDENTIFIED FLYING OBJECT

Can you identify this airplane?

The airplane pictured above is a

- **Starcraft SK700**
- **Schweizer RU-38A**
- **Dornier Do-335**
- **Cessna Skymaster**

For the fifth in our series of six contests, we've turned to one of the occasional canard designs that have popped up throughout aviation history. Original rules still apply: You can qualify for six prizes, one of which will be awarded after each photograph is published, and one grand prize at the conclusion of the contest:

awarded following each edition:
a Garmin GPS III satellite navigator

Grand Prize:
flight training worth $2,000 from the Be-A-Pilot™ program

All you have to do is select an answer from the choices listed above, then mail a postcard with your name, address, and answer to: Air & Space, UFO Contest, 901 D Street SW, 10th floor, Washington, DC 20024. Identify the airplane correctly and you'll qualify for the drawing to award the prize.

Before entering, please read the detailed rules, which are posted on page 86.

WINNER WINNER WINNER WINNER WINNER WINNER WINNER

Winner of the third UFO Contest is **Cleon R. Gleason** of Texas, who correctly identified the **Transavia PL-12 Airtruk**, a crop duster from Down Under with an unusual configuration.

issue. Alas, the Canadarm is now in U.S. hands. The robotics division of Spar Aerospace was sold earlier this year to American-owned MacDonald Dettwiler and Associates for $63 million (Canadian dollars). Not a bad deal, eh, when you consider that one of Canada's greatest contributions to space was built with about half a billion dollars of Canadian taxpayers' money. Another contribution, Spar's RadarSat satellite, also built with about a half a billion of Canadian tax dollars, was sold last year to the U.S. corporation Electromagnetic Sciences for only $30 million!

—David M. Robertson
Montreal, Quebec

Planning Ahead

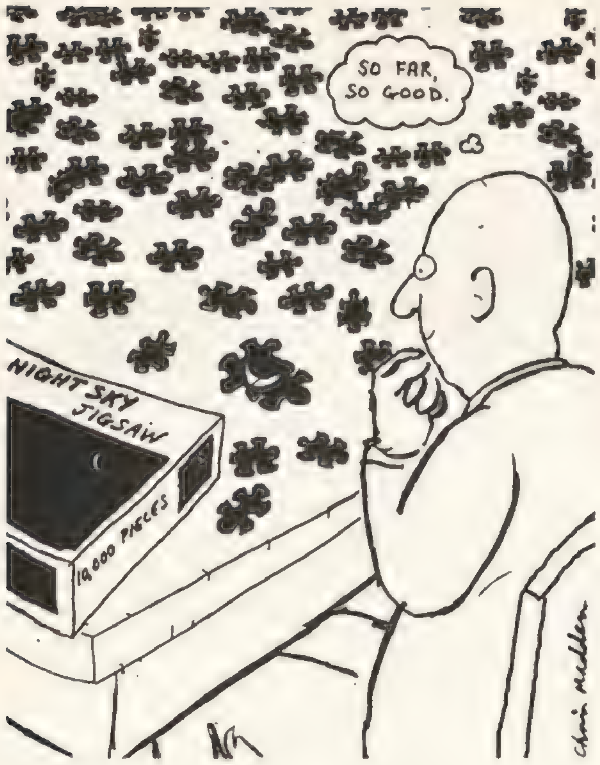
"Musical Airplanes" (In the Museum, June/July 1999) reminded me of something I saw while stationed at Ellsworth Air Force Base in Rapid City, South Dakota. A contractor had completed a hangar for maintenance of six RB-36s. I was officer of the day and watched as they tried to fit six planes in the hangar. No matter how they tried, the tail of the last airplane always stuck out the door. After a week of trying, they gave up. We found out later that the engineers had merely taken six cutouts of RB-36s, placed them in the best order, and drawn a square around them to determine the size of the hangar. No one had figured ahead on the spacing needed to get them through the door. I understand one of the senators from South Dakota interceded with the Pentagon and the contractor was paid in full. A month later, I was on the flight that took a pallet load of beer aloft so that it would be cold for the dedication of the hangar. In my mind, this piled waste upon inefficiency.

—Douglas R. Williams
Rogue River, Oregon

Conscientious Objection

The title "Drugnet" (June/July 1999) and the subhead lead people to believe the drug cartels will fail at attempts to get drugs into America. The reality, as stated later in the article, is exactly the reverse. Customs officials estimate they intercept less than five percent of cocaine and heroin bound for this country. People ask: Why don't we do more? They should ask: Why do we do it at all?

As an air traffic controller for 15 years, I've seen plenty of antics performed by customs cowboys. When the Drug War efforts moved into high gear during the



mid-1980s, customs aircraft were required to squawk a particular transponder code. As I watched them travel through my airspace in southern Texas, I was ordered by my supervisors to not issue traffic advisories to any aircraft that was being tailed or intercepted by a customs plane. Ironic: The very first paragraph of the 7110.65—the air traffic bible—tells me my first priority is to separate aircraft. Here I had management telling me not to, in the name of the Drug War.

The final straw was when the shuttle-carrying NASA 747 was returning from California. Five minutes ahead of them was a KC-135 acting as a turbulence warning aircraft. At 13,500 feet and slow, the KC-135 must have looked like an inviting target as a customs plane vectored in for the intercept. This was ridiculous. From 10 miles, the customs cowboys could easily tell this aircraft did not fit the drug-carrying profile. Against orders, I issued traffic to the tanker pilot. The pilot asked, "What the hell is this guy up to?" I wanted to know too.

This article was akin to the ones I read during Vietnam about our brilliant strategies and combat vehicles. It was full of similar actions: "If they see something fishy," and "We're looking for an anomaly." Then I read about the huge improvements in technology and the giant expenditures—now up to $18 billion—to fight the Drug War. I see all this as I think of the monitors at the tower I operate in—the same monitors that have been there since the 1960s.

—Mike Smithson
Syracuse, New York

Duck!

"The Pelican Brief" (Soundings, Feb./Mar. 1999) reminded me of an incident my brother was involved in several years ago while flying in Maryland with his son in the family Cessna 172. A light rain fell over the region, but the ceilings and visibility were good for night VFR cross-country flying.

Suddenly there was a bang, a loud roar, shards of windshield, and several duck carcasses slamming through the cabin. My brother's face was shredded from windshield fragments and bleeding profusely, and his contacts were knocked out of his eyes. My nephew held a flashlight and, using a shirt recovered from a canvas bag, wiped the blood from my brother's face.

They managed a 180-degree turn back to Tipton Army Airfield, and my brother got an emergency call to a Baltimore controller. With his son yelling directions toward the beacon at Tipton, he managed to keep the airplane flying. With full power and an airspeed of 105 mph, they descended at 800 feet per minute. If they descended at a slower rate, the airplane would pitch violently. Unable to see due to the blood and the loss of his contacts—not to mention a duck hanging in front of him—my brother and his son still landed safely.

—Steve Van Kirk
Mt. Airy, Maryland

Blackbird Budget

In the April/May 1999 issue the editor responded to Al Kirschenbaum's letter on a return of the SR-71 by stating that the principal obstacle "is the astronomical cost of keeping the aircraft flyable and in a state of operational readiness." This statement does not withstand logical analysis. Using the Air Force's own figures, it costs about $37,000 per hour to operate the SR-71, certainly more than an F-16 but far, far less than a B-1 or B-2. The SR-71 costs about five times as much per hour as a U-2, but it only needs one-fourth the hours to cover even more territory. Plus, it doesn't require the protective assets, which also cost money. The budget for the entire restored program was $33 million per year, and the Air Force usually came in below budget. The program budget appropriated for fiscal year 1997 before the veto was $39 million, but that included buying spare parts for expanded operations, sensor upgrades, and starting to return another Blackbird to service. To put these numbers in perspective, for the cost of orbiting (but not actually operating) one several-hundred-million-dollar satellite, you could run the entire SR-71 program for up to 30 years!

—Art Hanley
Sacramento, California

Hold Your Fire

My 357th Fighter Group, the same group that spawned Chuck Yeager, was no more and no less guilty of firing on friendly aircraft than most other fighter groups, I'm sure. The examples in "MiG Fever" (Above & Beyond, Apr./May 1999) and the next issue's Letters impressed me again with the need for a positive ID.

One day I chased off an Me 109 that was attacking a lone B-17. The pilot ran for the deck of clouds below and succeeded in reaching them before I was in firing range. I leveled out over his approximate position and was rewarded with a faint glimpse of him in the clouds. I knew he would eventually ascend or descend, and I planned to be waiting for him when he did. Soon the dark figure of a fighter eased out of the clouds right in front of me. Bingo, I had him! But going from staring at bright snow-like clouds for a few minutes to the darkness below prevented me from being sure the dark fighter was a 109 and not a wandering P-51. I risked giving up the easiest kill imaginable to ease up for a positive ID—and hoped he wouldn't spot me. He didn't, and once I had confirmed his identity, I was able to slip behind him to let six .50-calibers do their job.

—Harvey F. Mace
Fort Bragg, California

Corrections

June/July 1999 "Car Talk" (Above and Beyond): The credit for the photograph should have read "Bertha M. Ryan," not "NASA."

Feb./Mar. 1999 Sightings: The expedition aircraft's Pegasus engines were made by Bristol, not Westland.

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WINNER
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PC GAMER
EDITORS'
CHOICE
COMPUTER
GAMES
AWARD
WINNER
1998 SIMULATION
GAMESPOT
GAME OF THE YEAR
c|net
98 Award Winner
CNET Gamecenter
"European Air War's outstanding gameplay and wealth of features make it the current leader of the WWII simulation crop" -PC Gamer, 89%, Editor's Choice Award
"This World War II simulation captured the feeling of being in a living, unpredictable combat environment better than any other sim released this past year" -Computer Gaming World, 4 stars
"European Air War succeeds at providing the experience that makes arm-chair fighter pilots believe they're truly leaving their mundane surroundings behind" -Gamespot
RACKING UP
"No previous sim covers so many different weapons and so many tasks in detail... it's all here and it's all beautifully executed" -PC Gamer, 95%, Editor's Choice Award
"Falcon 4.0 is the deepest, most complex air combat sim yet... The campaign also creates the greatest sense of playing a small but important part of a huge battle" -PC Gamer
FALCON
4.0
TEEN
T
"Thoughtful gameplay design and the effort to bring players a sense of the true fighter pilot's experience can be felt throughout the game" -Computer Games Strategy Plus


EUROPEAN
AIR WAR
MICROPROSE
"European Air War combined huge dog fights, a great campaign system and realistic physics to make a game that was very hard to put down"
-IGN PC.com, Sim of the Year
"The care and attention to detail that went into every aspect of European Air War, from the hefty manual to the bomber nose art, represents a serious achievement"
-CNET GameCenter
THE KILLS!
"Bottom line: this sets the new standard in flight sims"
-Washington Post
"Falcon 4.0 is an incredibly detailed simulation that in many ways exceeds training systems in military use."
-Computer Gaming World
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Lost, Found, and Foundered

When Gus Grissom returned to Earth after the second U.S. manned spaceflight in July 1961, the hatch of his Mercury capsule, the *Liberty Bell 7*, blew out upon splashdown and Grissom nearly died. For 38 years, the capsule has rested undisturbed in its ocean grave. But it may soon return to terra firma.

Underwater salvage experts located the capsule on the first try last May in three-mile-deep waters about 90 miles northeast of the Bahamas. The speedy find stunned even expedition leader Curt Newport, a search and salvage expert who had spent 14 years researching the capsule's location and trying to raise money to rescue the spacecraft (see "Taking Liberty," Soundings, Dec. 1988/Jan. 1989).

Newport finally got a chance to conduct a methodical search, courtesy of the Discovery Channel, which picked up the tab in return for access to produce a documentary on the project that will air late this year. The team leased an oil rig work boat, loaded up 17 truckloads of gear, including two unmanned submersibles, and set sail from Port Canaveral, Florida, in mid-April.

Once the ship was at the 24-square-mile search area plotted by Newport, Oceaneering International, which conducted the search and salvage operation, launched the first of two underwater sleuths. The Ocean Explorer 6000 is a side-scan sonar that can map three-mile-wide swaths of the seabed in one go—once it gets going. Problems with the submersible, including a nearly catastrophic flooding of its electronics compartment, delayed the search for a few days. Towing the submersible on a four-mile-tether was slow work that required the ship captains to steer the vessel along a straight line for eight hours at a stretch. Turning around to get into position for the next search line took forever. Work proceeded smoothly for a week, but Newport's days at sea were running short: His contract called for a return to port in two weeks—with or without the capsule.

DISCOVERY CHANNEL ONLINE

Technicians sorted through 88 targets spotted by the side-scan sonar and narrowed down the list to 15 contenders. The team from Oceaneering then fielded its second submersible, a remotely operated vehicle named Magellan. Getting Magellan to the floor of the ocean took over four hours, and once it arrived, there was bad news: The submersible's sonar wasn't working, and trying to find targets with only camera views would be a waste of time.

"I was thinking: *This is a waste of time and money. We're never going to find the capsule*," says Newport.

Oceaneering's onboard manager, Steve Wright, gave the order to retrieve Magellan. But as the team prepared to pull it up, the weather, which had been threatening for hours, took a turn for the worse. As the boat started heaving from side to side, Wright decided to keep the submersible in the water. Technician Mark Wilson tweaked the feeble sonar as best he could and the two began piloting Magellan around the first search area, in hopes of stumbling upon Target No. 71, one of the likeliest suspects.

For nearly two hours, men and machine scoured the ocean floor. They found a pipe. They found a can that looked like it was leaking tomato sauce. Then, as Newport prepared to call it a day, they found a strange chunk that looked like a creased ice cube. There was another chunk a short distance away. And another…and another. The sonar, hampered by the hilly terrain, started pinging.

Just beyond the illumination of Magellan's lights, something stood tall. Wright maneuvered closer. It was the capsule, surrounded by the remains of its heat shield—the source of the creased cubes. The cameras caught the words "United States" painted on the craft.

"I was totally shocked," says Newport. "I could not believe that we had managed to find this thing while searching for our first sonar contact."

The joy aboard the ship lasted just 45 minutes. The storms grew worse and the boat pitched and strained at the cable that anchored Magellan to the ship. Eventually it snagged on its guide and frayed, blossoming into a two-foot-wide mess of wires.

The team struggled for hours to strip away the weakened wire so the tether could be reeled up and Magellan's 5,500 pounds transferred to a stronger section of cable. Just when it looked like Magellan was safe, the cable snapped and the submersible sank. Now there are two exploration vehicles awaiting rescue.

"There was really nothing left that we could do," said Newport. "We secured our deck gear and got under way for Port Canaveral. I can't think of a more perfect example of triumph and tragedy."

Newport and his team returned to the site with a new ROV to retrieve Magellan and *Liberty Bell 7* as this issue went to press. Once on land, the capsule will be restored by the Kansas Cosmosphere and Space Center in Hutchinson, Kansas, then sent on tour.

—Irene Brown

Pounding the Pavement

The United States has a weight problem. The trouble lies not just in the growth of our waistlines but also in the expanding capacity of our jetliners: In the next decade a fully loaded Boeing 777 could tip the scales at 1.1 million pounds, almost double the average heft of an airliner today. All this extra poundage is going to weigh mightily on airport pavement—but in what way, exactly, no one can say. "We know what weather will do to concrete and asphalt," says engineer William Mitchell, "but we don't know how they will react with more than a million pounds of airplane on them." Yet each year the Federal Aviation Administration spends $1 billion improving airport surfaces. So the FAA and Boeing have teamed up to build a $21 million facility near Atlantic City, New Jersey, designed solely to tear up some pavement.

Known as the National Airport Pavement Testing Facility and officially opened last April, it's housed in a narrow white prefabricated building four football fields long. The floor looks like a 60-foot-wide runway, but what this facility tests is not the stress of a jet slamming down on or lifting off from a runway. "When an airplane lands, it's still flying," explains project engineer Thomas Kanzler. "The weight is still on the wings—there's no such thing as input as far as the pavement is concerned." What pavement considers "input" is a fully loaded aircraft creeping to and from the gate, or just resting on the ramp.

To mimic that kind of stress, Kanzler designed the 1.1 million-pound Test Vehicle. "Saving weight was not an issue here," Kanzler says. Neither was aesthetics. It's a machine only an engineer could love. The vehicle resembles a steel bridge span painted institutional green. It rolls sideways on two railroad tracks that run along either side of the test pavement. Below the vehicle's main span are two perpendicular structures, from which bristle a plethora of the landing gear that equip today's jets.

The Sisyphus of heavy machinery, the Test Vehicle chugs ceaselessly back and forth on the test pavement at 5 to 15 mph—24 hours a day, seven days a week—until the surface fails, which could take roughly 18 months. Onboard computers and hydraulics can configure the landing gears to mimic the weights and tire layouts of any existing or proposed airliner. Beneath the surface, more than 1,000 sensors constantly monitor the strain, deflection, pressure, moisture, and temperature of the doomed test pavement—which itself consists of nine test sections of different depths and flexibilities.

"Our goal is to find out the mechanics of failure in pavements," says FAA project manager Satish Agrawal. "Airports have to follow the standards we are developing right here." In other words, they're searching for the optimal thickness of pavement. The test section that holds up the best will become the designated airport pavement of the future—for the time being. Agrawal says the testers will continue to develop longer-lasting and cheaper paving materials to replace today's asphalts and concretes. They'll also attempt to learn more about the effects of different landing gear configurations. The National Airport Pavement Testing Facility is expected to be in business for 15 years.

—Phil Scott

MICHAEL GOODMAN PHOTOGRAPHY

UPDATE

The Osprey Has Landed

The U.S. Marines took delivery of the first production V-22 Osprey last May ("Extreme Machine," Oct./Nov. 1998). The Corps is due another 359 tiltrotors. The U.S. Air Force Special Operations Command has 50 on order; the U.S. Navy, 48.

Science Fair at 30,000 Feet

Stephen Smith and his three buddies from Embry-Riddle Aeronautical University in Daytona Beach, Florida, are embarrassed to admit it now, but when they proposed building a better toolbox for spacewalking repair crews, the thought that they were helping to advance technology didn't cross their minds. "All we wanted to do," says Smith, a junior, "was win a ride on the Vomit Comet." That's the KC-135A, a NASA research aircraft that brings the weightlessness of space to the non-astronaut. For the third year running, NASA is offering rides to high school and college students whose experiments—all needing zero gravity to work—are judged worthy. Two rounds of flights took place last March and April, and the next is scheduled for August.

The modified Boeing tanker's official name is Weightless Wonder 5. But most of those who've ridden along as it flies 40 8,000-feet parabolic arcs in succession know all too well why it earned its other moniker. "Getting sick but smiling," says Tyrone Mercer, who rode the ultimate roller coaster in March. "On a fun scale of 1 to 10? This is an 11."

To be invited aboard, the students had to win over the selection committee for NASA's 1999 Reduced Gravity Student Flight Opportunities Program. The chosen experiments for the March

NASA

session ranged from solving a Rubik's Cube to producing carbon nanotubes.

Smith and Mercer, along with team leader Adam Schwimmer and Carmelo Marino, dreamed up just what the judges ordered. It's a system of metal cables that can be attached to tools and will reel out, then spool back with a tug, like the power cord on a canister vacuum cleaner. "We think this retractable tether system will make it easier to locate and use tools that tend to float away in a microgravity environment," explains Schwimmer.

They joined two teams from their own school and 41 others from across the country at NASA's Johnson Space Center in Houston. Embry-Riddle invited *Air & Space* along for the two-week field trip. Participants had to submit to medical checkups, a day-long lecture on the physiology of flight, and, finally, an altitude chamber in which they breathed themselves into a stupor on rarefied air to experience the onset of hypoxia.

The aircraft traces a square in the sky over the Gulf of Mexico from Houston south to Brownsville. On each side of the square, it flies 10 parabolas, each time climbing to 32,000 feet and falling back to 24,000 feet in about 60 seconds. Over the top, for about 25 seconds, gravity is next to nothing. Everything floats. It's the 2-G sensation on the way up and down that takes the biggest toll. Some students get so sick they have to ride out the flight strapped in their seats. "Your mind is abused," says Marino. "Your body's abused."

All four Embry-Riddle guys still want to be airline pilots, not astronauts. But Schwimmer and Marino were so bitten by the zero-G bug that they lined up for a chance to ride again in August—and got it. "We really want to see whether we're creating something of value for the astronauts," Schwimmer says.

Later, over a bowl of beans and rice at PeTe's Cajun Bar-B-Q, just outside the airport—a ritual for KC-135 initiates—we compared notes. The measure of your success is the number of parabolas you can fly before getting sick. I lasted 28—quite respectable, I'm told.

—Beth Dickey

UPDATE

Austin Towers

Austin-Bergstrom International Airport in Texas, a phoenix risen from the ashes of a closed Air Combat Command base ("The End," June/July 1997), opened for business last May. The converted facility has a 12,250-foot runway and 25 gates. Austin's 1930s-vintage airport, Robert Mueller Municipal, with its 7,000-foot runway and 16 gates, was closed at midnight on the night before the new airport opened.

Chris Craft

"The Admiralty said it was a plane and not a boat, the Royal Air Force said it was a boat and not a plane, the Army were plain not interested," the father of the hovercraft once said. Inauspicious beginnings for the air-cushion vehicle invented by Sir Christopher Cockerell, who died last June at his home in Hampshire, England. His death came four days short of his 89th birthday and almost 40 years to the day after his invention's first flight.

Christopher Cockerell had quit British

COURTESY GKN WESTLAND LIMITED

Marconi (where he had been instrumental in the development of radar) soon after the end of World War II so he could buy a boat-building business in Norfolk, England. In trying to reduce drag on a boat's hull, he modified a punt to float on a cushion of air. Once officials at Britain's Ministry of Supply heard the idea, they promptly put development of the principle on a list of secret programs. It was not until eight years after the patent was initiated that the first man-carrying amphibious hovercraft, the Saunders-Roe Nautical 1, flew in Southampton water.

Despite the initial disdain with which Britain's military services regarded the early hovercraft, it has become one of the most significant transport inventions of the 20th century—so much so that it has been chosen to represent the year 1959 in the 100 words that sum up the 20th century for a "Millennium" edition of the Collins English Dictionary.

Today's hovercraft skim the surface on a cushion of air generated by lift fans. The U.S. Navy owns dozens of a giant version of the vehicle, designated Landing Craft Air Cushion. The former Soviet forces are estimated to have 250. Offering heavy lift capability and high speed, hovercraft can operate on mudflats, coral reefs, shallow waters, marshes, and crude beaches. Hovercraft have carried 80 million passengers and 12 million cars across the English Channel. In 1998, exports of the craft from British manufacturers reached over $30 million. The Canadians and Finns use them for coast guard duties, the Nigerians use them as crew boats for oil fields, and Hong Kong uses them for fishery protection work.

Cockerell shared in little of this success. At one point in the 1950s, while the Ministry of Supply sat on his patents, Cockerell was forced to pawn his mother-in-law's engagement ring to stay afloat. When the U.S. government paid $5 million to the British Technology Group years later for the rights to develop the hovercraft for military use, Cockerell was told that the fee paid to him previously—about $50,000 after taxes and development costs—had fully satisfied the government's obligations.

Last May, to commemorate the 40th anniversary of the craft's first flight, the Hovercraft Trust and Museum staged a flyby at Lee-on-Solent, to which Sir Christopher was invited. Too frail to attend, he sent his best wishes. He died the following day.

—Stephen Bloomfield

John Glenn Rides Again

"Would I like to go back up again? Yes, I'd like to go back up again." So admitted former Mercury astronaut John Glenn when asked if he wanted a second ride on NASA's space shuttle. Glenn's much publicized launch into orbit on October 29, 1998, gave the 77-year-old retired U.S. senator the distinction of being the oldest person to travel into space. Last April, he thrilled a full house at the National Air and Space Museum's Langley Theater, where he took to the podium to rhapsodize about the flight.

Glenn, who in February 1962 became the first American to orbit Earth, started the evening with a bit of comedy. "Space is almost ideal for a retirement community," he said. "If you spill some food, it doesn't go on your tie. It just floats out in front of you. You don't fall; we're not going to need any canes and walkers and wheelchairs. And if you happen to be an old person and you have trouble sleeping, don't worry about it. There will be another night along in 45 minutes anyway so you can try again."

Glenn, a graceful speaker, then shifted into an account of his personal experiences aboard the shuttle *Discovery*. "You're weightless," he said. "You're floating. Just like Superman. And it's fun." So was quenching his thirst. "You can take a water container and squeeze water out of it," he said. "And if you have a little golfball-size [portion of water] and it's floating out here, you can go out and [makes sipping sound] get a drink of water just like that.

"Your view from up there is something that's very hard to over-emphasize," he continued. "We were up about 350 statute miles and that gives you a pretty good view. We came over the southern part of Florida, down in the Keys, on about the third or fourth day, and I happened to be done with the experiments I'd been running and looked out the window and could see clear up the East Coast—clear up into Canada. I would see the Great Lakes, Cape Cod, and Long Island Sound."

Glenn then quickly moved on to a discussion of what could be learned by sending an older person into space. "That was the reason I was sent up," he said. "It wasn't just being sent up as a favor to me because I wanted to go up again." During the nine-day mission, Glenn was the subject of dozens of experiments, which studied everything from his sleep patterns to his bone and muscle metabolism. He gave blood 12 times, and for four nights as he slept, his body was covered with a mass of wires and electrodes. "But I feel fine and I hope we've gotten some good information," he said.

As for returning to orbit, he said: "I recommend it for every single one of you. I hope you can go to space." So do we, John, so do we.

—Diane Tedeschi

ROBERT REEDER

NASM

On February 20, 1962, John Glenn, riding inside the Friendship 7 *capsule (above), became the first American to orbit Earth. Thirty-six years later, Glenn suited up for his second trip into space.*

A Surprising Gift

Though he had traveled the world, visiting the National Air and Space Museum remained one of the late Karl Hagen's favorite activities. Hagen, who died on March 18 at the age of 89, was the son of German immigrants and a member of the Army Signal Corps during World War II. Though he worked 36 years in Washington, D.C., as a foreman for the Potomac Electric Power Company and invested wisely in the stock market, Hagen lived so frugally that few would have guessed how wealthy he had become. Over the years, the lifelong bachelor developed interests in history, geography, and machinery, and in the Museum he found a place where many of his passions intersected. So it was fitting that he remember the Museum in his will, which bestowed a gift of approximately $1 million.

Hagen had also made donations to the Museum during his lifetime; his first was a World War I-era German parade helmet that had belonged to his family. He later established a charitable trust with the Museum as a beneficiary. Those who knew Hagen are not surprised at his generosity. Says Valentino Sacco, Hagen's longtime friend and executor: "He just fell in love with the Museum and wanted to make sure people could continue enjoying it in the future."

—*Cherie Wasoff*

MUSEUM CALENDAR

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.

August 28 Monthly Star Lecture: "You are Starstuff!" Take a tour of the night skies of summer and autumn with Steve Smith, the planetarium educator for the Arlington, Virginia school district. Smith will also use images taken by the Hubble Space Telescope to illustrate the life cycle of stars. He will conclude with a discussion of the question "What is our place in the universe?" Einstein Planetarium, 6 p.m.

FUN & GAMES

ERIC LONG (2)

The Museum has four 1950s-vintage aviation- and space-theme arcade games, including the Whirly Bird (left), which, for a dime, tests a player's ability to maneuver a helicopter around a hill.

ANNIVERSARIES

April 30 marked the 37th anniversary of the first flight of the Lockheed A-12, the aircraft that became the basis for the fabled SR-71 Blackbird. Former Lockheed test pilot Lou Schalk (right), who made the historic flight, met with Museum aeronautics curator and former Blackbird pilot Tom Alison (left) to view the Museum's SR-71, which is in storage at Washington Dulles International Airport in Virginia. Schalk made the A-12's first four Mach 3 flights, reaching a top speed of Mach 3.287, or 2,276 mph, and an altitude of more than 90,000 feet.

Thirty Seconds Over Philmont

In the 1960s, I worked in a New York advertising agency. I was having a bad run of luck. Private memos to Joe wound up in the hands of Harry, people kept giving me hurt, moist-eyed looks when I lit my pipe, and I spent days fretting over a simple-minded institutional ad for an insurance company.

I was convinced I was on my way 'round the bend. In a wistful way I toyed with the notion of going back to active flying status with the Air Force, disregarding the fact that I hadn't been at the controls of an airplane in 20 years—not to mention that the military would have no interest whatsoever in a 40ish ex-pilot in dubious mental and physical shape.

I had to get away. I told the creative director I wanted to take vacation time and maybe some leave of absence.

Years before, while trout fishing, I had happened upon an idyllic getaway, an honest-to-God country inn with the bark still on it—the Vanderbilt, in Philmont, New York, about 130 miles north of Manhattan. The next day I carried my bag into the lobby.

DAVID CLARK

You had to walk only the three-block length of Main Street to find all Philmont had to offer. There was a filling station, a saloon, a bank, a grocery store, another saloon, a place called The Fair Deal Trading Post, which you wouldn't go into without a lawyer and a professional appraiser, a drugstore, a library that was open from 2 to 4 on Tuesdays and Thursdays, another saloon, a church, and a laundromat—on account of cleanliness being next to godliness, I supposed. In Philmont it was across the street.

At lunchtime I sat at the bar and talked with the proprietor of the Vanderbilt, a redheaded fireplug of a man named Bud Wildermuth. He was a year younger than I and had been a gunner on B-17s flying out of England. When I told him I'd flown B-26s and A-26s, he said I ought to meet Phil Richardson, who was older than Bud and me, had been flying all his life, had done some ferrying during the war, and was still flying out of the Columbia County Airport. Two minutes later Phil Richardson walked into the place.

He was tall, lean, intense, and pumped with enthusiasm for everything, especially flying. "I have the use of a plane anytime I want it," he told me when he learned I'd once flown. "We'll have to go up, first chance you have. Yes, yes."

"Weather has to be flawless," I said. Despite my daydreams about the Air Force, I could not find any enthusiasm. For me, flying the Martin B-26 Marauder had taken all the bloom off the wild blue yonder.

In the next week I found out a lot about Phil Richardson. He seemed to be semi-retired, with his fingers in a lot of pies. He owned a hardware store, mostly closed, and a hotel, next to the hardware store, closed except for a room now and then if he thought someone needed it. Downstairs was a bar, open whenever Phil felt like opening it. For those special people Phil knew were running for the office of town drunk, he'd serve a bowl of soup or beef stew before giving them a drink. He was dedicated to helping those he thought could use help. I think he considered me another reclamation project. Every time I saw him, he'd invite me to go flying with him, yes, yes. My answer was always no, no.

One sunny day he came looking for me as I was having lunch at the bar of the Vanderbilt. He was even more pumped up than usual. "Clambake tomorrow. VFW. I'm flying the clams over from Long Island. Need you as copilot."

"I've got something in the typewriter I've got to finish," I told him. "It's going to take me a couple of days."

"Take tomorrow afternoon off," Phil said. "Fly to Long Island with me. Do you good."

"Thanks, Phil," I said, "but no thank

you." He left, mystified at the spectacle of an ex-pilot who didn't want to fly. Maybe he was beginning to doubt I'd ever been a pilot. I didn't care. I didn't feel like flying to Long Island and back, clams or no clams.

Around noon the next day he banged on the door of my room and opened it before I could answer. I had my feet up and was reading the *New York Times.*

"I need you for that trip to Long Island," he said. "Them clams're waitin'."

"You need a copilot to fly clams?" I asked.

"I need someone to help me load, is what I need," Phil said. "Fella I had lined up had to do something else. Those goddamn bags of clams are heavy."

I threw the *Times* on the bed and stood up. "Let's go," I said.

The airplane was a high-wing job with a tailwheel and a radial engine. Seats were side by side. "Take the left seat," Phil said.

"No thanks," I said. "I'll ride copilot." I climbed in, fastened my seat belt, and looked around. It didn't look anything like any airplane I'd ever been in. My last few hundred hours of stick time had been in Douglas A-26 Invaders.

Phil got in and started the engine, warmed it, taxied out, and took off. He never looked at any checklist and after takeoff he never looked around; he would have washed out as a cadet.

When we reached altitude—somewhere within a couple hundred feet of 3,000—he turned to me and shouted, "Take it for a while. Fly a heading of 120."

I slid the seat forward until I was comfortable with the rudder pedals, applied a little back pressure on the stick to get us up to 3,000 feet, leveled off, and flew a heading of 120 degrees. The right wing wanted to climb, so I looked for the aileron trim tabs—up, down, around. Nothing.

"What are you looking for?" Phil hollered.

"Trim tabs for the ailerons. Right wing wants to ride high."

"What trim tabs? Hold a little right rudder."

I did, and the wing came down. I found that I had no trouble holding heading and altitude, although after the A-26, flying this was like transitioning from a Mercedes-Benz to a Model A Ford.

After a few minutes I looked over at Phil. He was sound asleep. *I'll fix this clamdigger,* I thought. *I'll throttle back, lift the nose until this thing stalls, and kick it into a spin. Then I'll wake him.*

But I didn't have the guts. After we crossed most of Long Island Sound and I had a town in sight on the North Shore, I woke Phil.

"Hey Lindbergh," I said. "Paris is dead ahead."

He woke up, looked around, and knew right away where we were. He took the controls and within 10 minutes he found the field he wanted, around Freeport somewhere, and we were on the ground.

On the trip back, Phil took the controls all the way. We'd lost a lot of time waiting for the man to come with the clams in his pickup, then lifting the heavy bags into the airplane.

As we came back over the sound the sky was no longer sunny. By the time we reached Columbia County, Phil was on instruments part of the time. As we got close to the airport, we were looking at a thunderstorm, dead ahead.

> Phil was dedicated to helping those he thought could use help. I think he considered me another reclamation project. Every time I saw him, he'd invite me to go flying with him, yes, yes. My answer was always no, no. For me, flying the Martin B-26 Marauder had taken all the bloom off the wild blue yonder.

Off to the west, around the Hudson River, the weather looked pretty clear—better, anyway, than what we were headed into. I tapped Phil on the shoulder. "Isn't there a field over around Rhinebeck somewhere?" I shouted over the engine.

"Yes, but we'd be too late. Too late for the clambake."

"The clambake!" I yelled, using a verb first.

He ignored me and banked to the right, toward Philmont. The weather looked bad that way too, but it wasn't a thunderstorm—not yet.

Closer to Philmont there was a break in the clouds, and Phil lost altitude with a big sideways slip. Philmont was right underneath us, and Phil flew up Main Street and bore right, toward the Grange Hall and the clambake.

"There's a field there, good field, yes, yes," Phil shouted at me.

I saw it, all right, but to this day I don't know how Phil got that airplane down in that little space, slipping in over high trees with the power all the way off. After we'd bounced to a stop, a pickup bounced toward us, with a couple of yahoos waving beefy arms out the windows. I looked over at Phil. "You're a better man than I am, Gunga Din," I said.

"What?"

"Nothing," I said. Two days later I was back in New York, on the ground, on Madison Avenue, where I belonged.

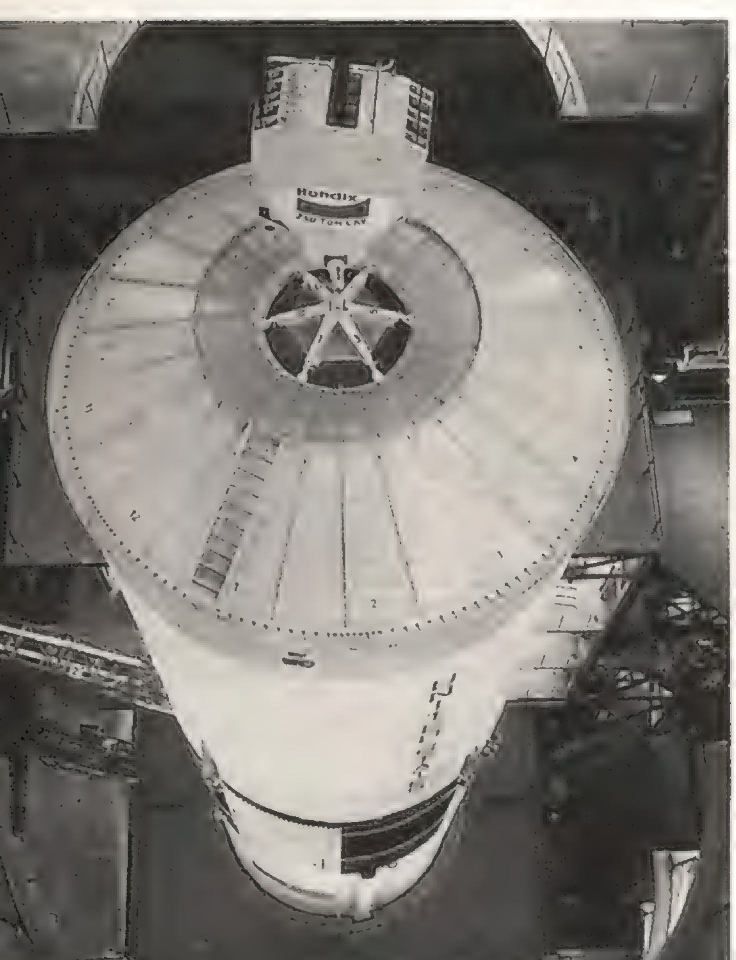
—Arnold Benson

Upstaged

It was a classic case of not seeing the forest for the trees. "Let's figure out how to move this mother from Downey to Seal Beach with the least excitement. Let's do it in no more than six weeks, so we can fold it into the proposal package. Let's do it! Go!"

It was 1961, and the speaker was Space General's director of operations, Jack Froehlich. The problem was how to transport a Saturn V launch vehicle's second stage, 30 feet in diameter and 80 feet long, from parent company Aerojet General's plant in Downey, California, 15 miles to the Pacific Ocean, where it could be loaded on a barge at Seal Beach. If we could find a solution, we stood a chance of winning a tough competition with North American, Convair, and Douglas.

Froehlich had come to Space General from the Jet Propulsion Laboratory in Pasadena. He was an outstanding engineer and a hard driver—acerbic, cocksure, and bullying. I admired his decisiveness in a technical world populated with ultra-conservative managers. His objective was to make Space General a major player in the aerospace industry. He was rabid to get us more involved in the testing program at the Nevada test site where the Aerojet General-developed nuclear rocket engine, the NERVA, was being perfected—which is how he won the nickname Flatass Jack of Jackass Flats.


NASA

Move it or lose it: The challenge was getting the 80-foot-long Saturn V second stage from the plant to the Pacific Ocean.

Flatass Jack's opportunity came with the proposal for developing and manufacturing the Saturn S-II stage. For upstart Space General to compete for this billion-dollar program by itself would have been foolhardy, but Space General could lead an all-out Aerojet General corporate effort. As chief engineer, I would be responsible for writing the technical part of the proposal and supplying personnel for the multitude of proposal tasks.

Aerojet had recently purchased the Rheem Manufacturing Company, known for its hot water heaters. Rheem was also a builder of large petrochemical tankage and had the experience and equipment to construct the oversize tankage that would make up most of the S-II stage. Another factor in our favor was Aerojet's Liquid Rocket Plant in Sacramento, where the complete stage could be test-fired. The catch, as Froehlich had informed us, was to find a way to transport the gigantic assembled stage the 15 miles from Downey to the sea. From there, a barge would have access to both the Sacramento delta and, via the Panama Canal, the inland waterway all the way to Cape Kennedy in Florida.

Flatass Jack organized a team to work on transport fixtures and loading and unloading methodology; marketeers, lawyers, and contract specialists to deal with fiscal and governmental authorities; and shipping personnel to determine optimum routing through the cities and towns along the way. The engineers determined that wide-body trailers could be built to carry the stages and still make cross-street turns, as long as a feasible highway routing could be found. But it was soon apparent that the along-the-road hazards were overwhelming: freeway underpasses were not big enough, telephone and power lines interfered, bridges were not wide enough or strong enough, and railroad track crossings were similarly narrow.

Several tortuous routing possibilities were developed and avidly pursued. Notarized agreements had to be made with each municipal and county fiefdom, as well as various highway departments, utility companies, and city and state police departments. Included were agreements to build ramps for 90-degree freeway crossings, middle-of-the-night usage of two-lane roads converted temporarily into one-way streets, removal of some kiosks and bus shelters, re-routing of overhead phone and power lines, temporary beefing up of a bridge, and rescheduling of some freight train and bus movements. Deals had to be tentatively cut with city, county, and state agencies, the transit authorities, and two railroad companies. Finally, just making the deadline, we had it made.

While we were all asses and elbows doing our proposal thing, North American engineers were busy lobbying NASA. They got the agency to accede to their "no test facility cost" proposal to conduct the stage's final test-firing at NASA's new engine test facility on the inland waterway at Bay St. Louis in Mississippi. This eliminated the problem of moving the stage from North American's assembly site to the engine manufacturer's test facility in the San Fernando Valley, which was just as land-locked as Aerojet's Downey plant. But the clincher was that North American got the Navy to donate land at its Seal Beach weapons center for a brand-new manufacturing and assembly plant, hard by the Navy docks, at minimal cost to NASA.

Of course they won the competition hands down. When we heard the bad news from NASA, Flatass Jack turned to me and said, "Bob, why the hell didn't we think of that?"

—R.F. Brodsky

SMITHSONIAN STUDY TOURS

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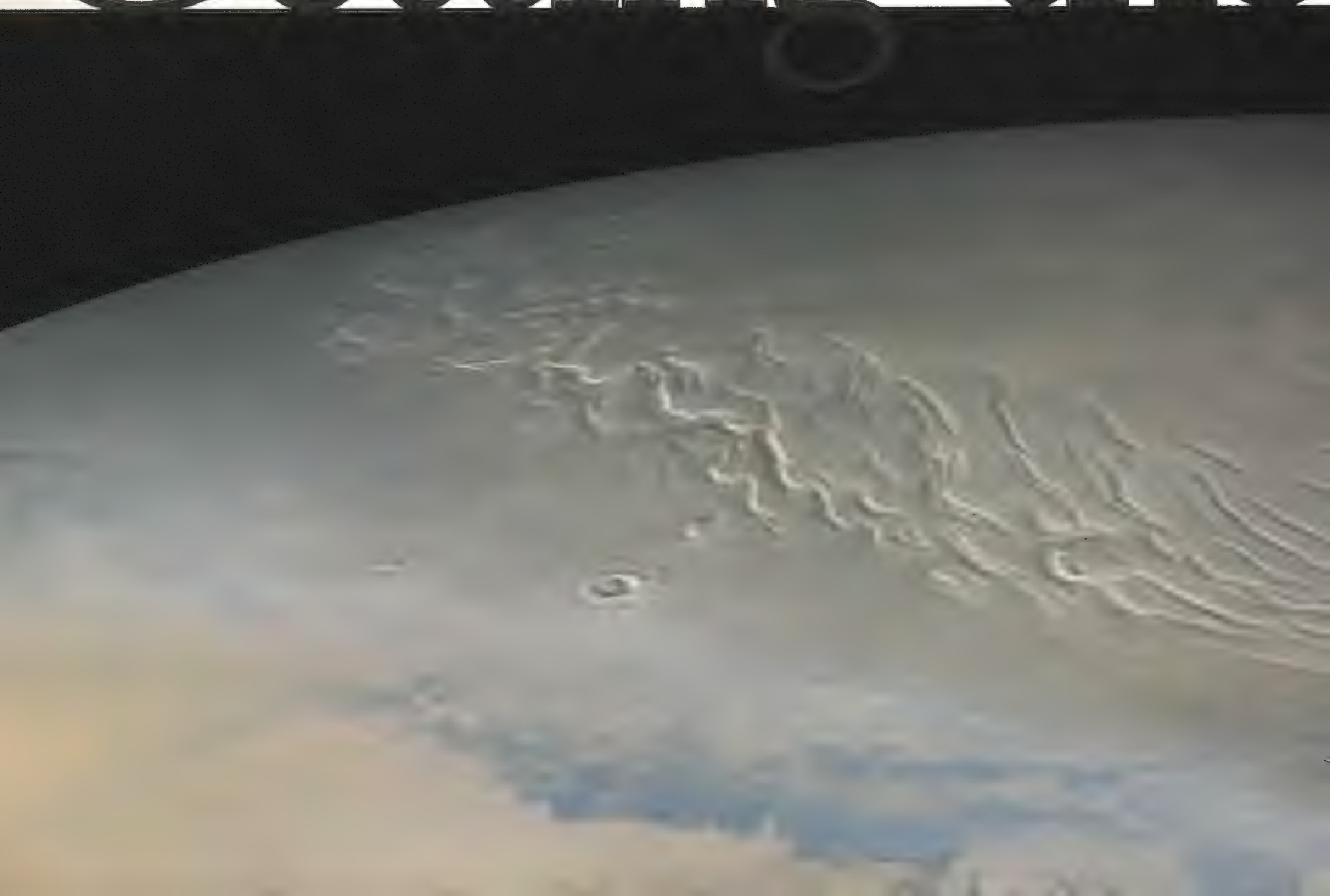


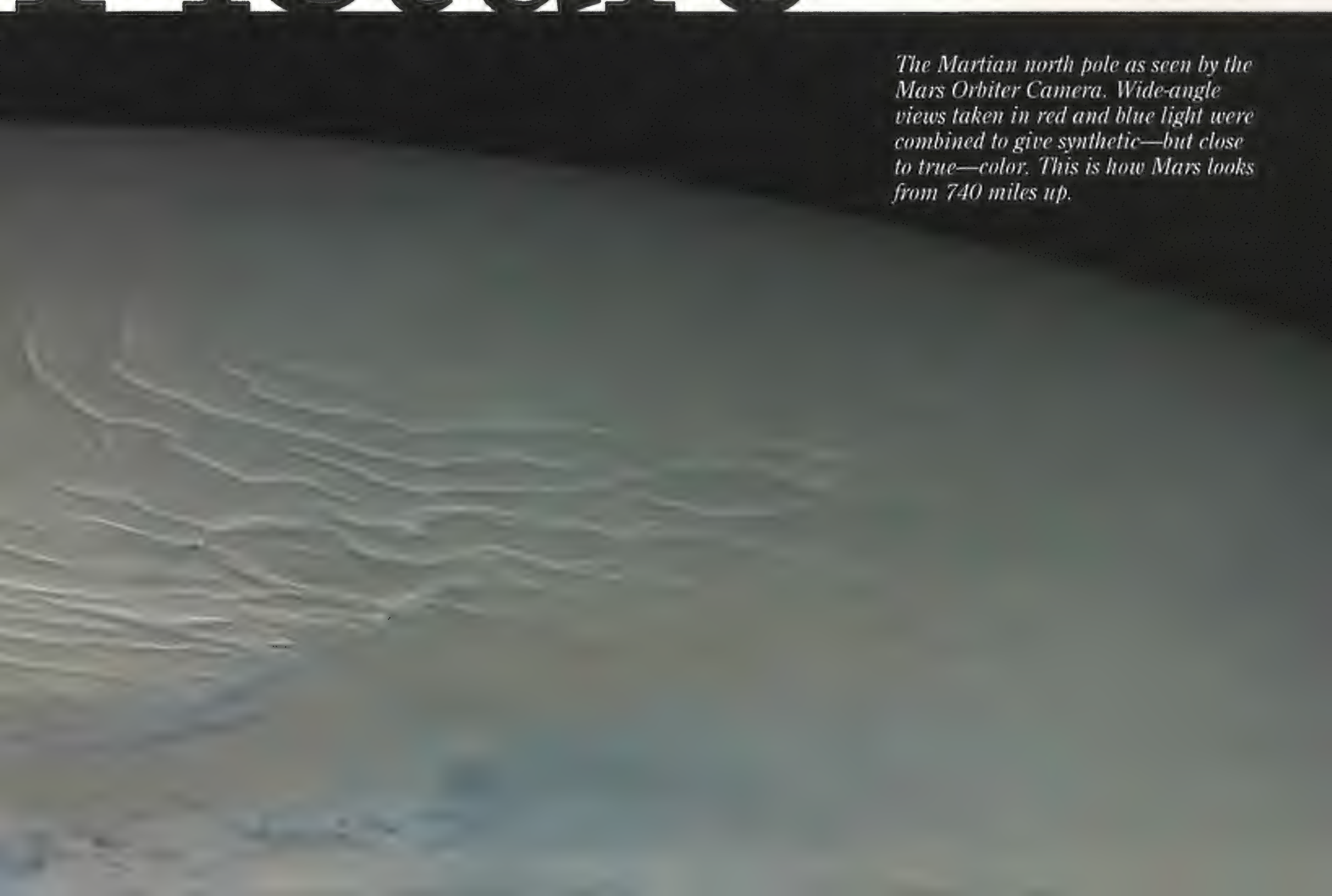
DESTINATION: MARS • FIRST OF A SERIES

NASA gets the cameras to Mars. Mike Malin does the rest.

by Henry S.F. Cooper Jr.

Picture

Of the 19,000 or so pictures that the Mars Global Surveyor has returned since it began orbiting Mars two years ago, Mike Malin has a particular favorite. It was taken on the spacecraft's 20th orbit: Tuesday, October 14, 1997, 13:20 Universal Time. "It was a mistake," recalls Malin. The camera had been sent a faulty command, so the exposure times were off. Still, what came back was a picture of a flat region called Elysium, with boulders just visible on the surface. That in itself was unremarkable, considering that the Viking landers had photographed plenty of rocks strewn about the red plains of Mars more than 20 years earlier. But for geologist and camera designer Malin, it was a vindication. "It was the first time we had ever seen rocks on Mars from orbit. It looks just like a place I worked in Iceland! Whenever I see rocks on Mars I get a thrill,



The Martian north pole as seen by the Mars Orbiter Camera. Wide-angle views taken in red and blue light were combined to give synthetic—but close to true—color. This is how Mars looks from 740 miles up.

KEITH SKELTON

Mike Malin—planetary scientist, company president, and guiding spirit behind the Mars Orbiter Camera—peers down into the instrument's optics.

because that is what the camera is designed to do. And it does it!"

Malin is the builder, operator, principal scientific investigator, and guiding spirit behind the Mars Orbiter Camera, the premier instrument on board the Mars Global Surveyor, which is the reconnaissance ship for an armada of more than 20 international spacecraft scheduled to visit the Red Planet between now and 2010. The camera's best pictures show details as small as five feet across—ten times the resolution of the Viking orbiters. No other planned mission will come close to matching that resolution from orbit, so Malin's Mars image archive will be the most detailed photographic record of the planet for a decade or more. It's an important responsibility that NASA and other Mars researchers have entrusted to Malin and his small company, but he has spent much of his life preparing for just this opportunity.

A slight, wiry man in his late 40s, Malin has been fascinated with Mars since his early teens. He loved science fiction, particularly the novels of Robert Heinlein, with whom he struck up an acquaintance as a teenager. At high school he was a good enough musician to play the trombone in the Los Angeles Symphony and get accepted at the Juilliard School of Music in New York. Instead he went to the University of California at Berkeley, where he majored in physics, and then to the California Institute of Technology, where he studied geology and planetary science under Bruce Murray, later director of the Caltech-operated Jet Propulsion Laboratory and a leading figure in the field of planetary exploration.

Working on the Mariner missions at JPL, Malin met Ed Danielson, a physicist working as the liaison between engineers designing cameras for the spacecraft and the mission scientists. Malin liked the mix of science and instrument engineering. Even as an undergraduate, he had learned that a thorough knowledge of equipment could be critical in research.

By the late 1970s official interest (and funding) was shifting away from Mars, but Malin stubbornly stuck to studying the Red Planet. Murray remembers that for his former student, it was a lonely period professionally. Malin went on field trips to the Colorado Plateau, Iceland, and Antarctica—all places that, one way or another, served as analogs to what he had seen in the Mariner 9 and Viking imagery of Mars.

"The real reason for going to these places was for what I call 'calibrating my eyes,' " he says today. "When you look at an aerial photo—straight down—you don't get any sense of the relief or of how smooth the slopes are or how wide they are. On the moon, craters looked craggy from orbit but were smooth on the ground."

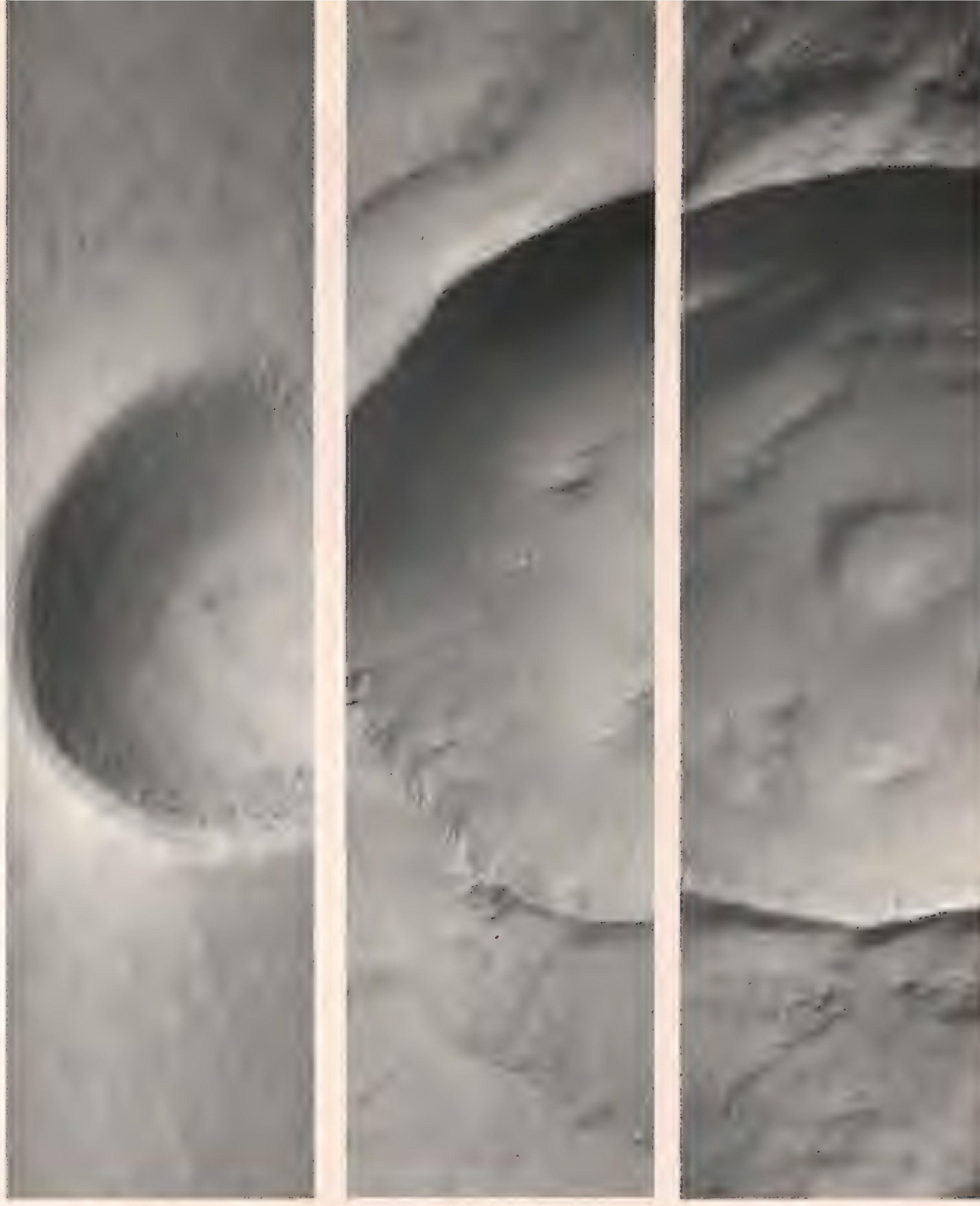
Dark sand dunes in the Syrtis Major region of Mars. This narrow-angle view covers an area 1.3 miles across.

In Iceland he studied valleys and plains where the melting of ice sheets by volcanic activity had once released catastrophic floods. He was struck by the number of boulders the floods had strewn across the landscape. "I learned quite a lot, walking around, measuring the size of the rocks," he remembers. On the Colorado Plateau, he visited places where water flowing underground had caused the surface terrain to slump. And in Antarctica he focused on chemical and physical erosion, closely studying what wind-blown sand or ice did to the rocks—all the kinds of processes one might expect to see on Mars.

In 1979 Malin moved to Arizona State University, where he eventually became a professor of geology. He stayed in touch with his friends at JPL, however, and got involved in various groups planning for Mars missions that never materialized. Then, in the early 1980s, NASA finally approved the Mars Observer project, which would study the planet's atmosphere and surface from orbit for a full Martian year. There was a hitch, though: The spacecraft would carry no camera. The existing Viking photos were good enough, so the argument went, and cameras weren't worth the extra weight, power, and data relay capability they demanded. "One scientist high up in NASA headquarters said there would be a camera only over his dead body," Malin recalls. But "a lot of my life and career has been going off in directions where people told me I can't do something. So Danielson and I took it as a challenge: What could we do to get an imaging system—a camera—on the next Mars mission?"

They lobbied. One person whose arm they twisted was Michael Carr, a planetary scientist at the U.S. Geological Survey in Menlo Park, California. Once leader of the Viking Orbiter imaging team, he was now in charge of the science working group for the new mission. If Carr's committee wouldn't approve a camera, Malin and Danielson at least wanted to make sure they didn't rule one out.

They figured if they could design a system that used only 10 percent of the



Photographs of Martian craters taken during the same week last May. All three are the scars of meteorite impacts. The largest (right) is about 4.5 miles across—seven times wider than Arizona's famous Meteor Crater.

ALL MARS PHOTOS COURTESY MALIN SPACE SCIENCE SYSTEMS/NASA

mass, power, data, and dollars allocated for the entire package of eight instruments, NASA would have a hard time turning them down. Malin tapped a couple of former Caltech students, Mike Ravine and Tom Soulanille, to help with the design. "We basically got together a group of eager young people who were not steeped in the old ways that JPL did things," Malin says. The team made a proposal, "and sure enough, we won, and the instrument was put on Mars Observer."

The result is indeed a model of elegant engineering. The 45-pound camera weighs less than half as much as the camera onboard the Cassini Saturn orbiter, costs (at $22 million) a quarter as much, and uses one-fourth the power.

The imaging system designed for the Mars Observer is really three cameras. In addition to the narrow-angle camera for black-and-white closeups, there are two wide-angle cameras with fish-eye lenses that see from horizon to horizon. These can produce a global "mosaic" image from just 12 orbital passes, yielding a new picture of the whole planet (and its weather) every day. One wide-angle camera has a red lens, the other a blue. The red filters out the Martian atmosphere and is thus ideal for viewing the ground and dust clouds; the blue is better for viewing water-ice clouds in the atmosphere, and shows the surface as dark.

Normally a camera needs three filters—red, blue, and green—to synthesize an accurate color picture. But experience with Viking pictures showed that green on Mars is pretty close to an average of red and blue, so Malin and his team figured they could make decent color images from the two wide-angle cameras, since the combined filters would simulate green. That decision alone saved perhaps a million dollars.

The high-resolution camera, though, is what makes the instrument special. Malin originally had wanted a camera that could resolve details down to a foot or two in size, so he could see even small rocks deposited by catastrophic floods in the Martian past. But when it became clear that such an instrument wouldn't fit within the Mars Observer mission's tight constraints, the team settled for a resolution of 1.5 meters (five feet) per picture element, or pixel. That would at least show the larger, truck-size boulders he had seen strewn around Icelandic valleys; the ability to detect similar objects on Mars would give valuable clues to past events such as floods and landslides.

No previous planetary camera had taken pictures this detailed from orbit. Mike Ravine, who is now the advanced project manager for the company Malin started, says that "taking [five-foot] resolution images from a spacecraft in orbit around Mars was actually a challenging thing to do." Exposure times would be measured in thousandths of a second, and sunlight falling on the planet would provide only half the illumination it does on Earth. The camera would sometimes be looking through a hazy atmosphere, and the imaging team wanted low sun angles and long shadows that would highlight topography. "You add all those factors up and there's not a lot of light," says Ravine.

The shortness of the exposure times is due to the novel way the camera takes its pictures. Past planetary spacecraft like Voyager, Galileo, and the Viking Mars orbiter had cameras mounted on a movable "scan platform" that panned as the picture was taken to counteract image smear caused by the spacecraft's motion and to take several mosaic frames of the same area. The light detectors on these spacecraft—whether vidicon systems or charge-coupled devices (CCDs)—produced a square-like image with up to 1,000 or so pixels on a side. On Viking, it took about nine seconds to acquire one of these frames and record it to tape.

Scan platforms are costly and complex, however, and the square "area array" cameras tend to be bulky. Malin

and his team looked at another solution, a line array—basically, a single row of 2,048 CCD detector pixels at the focus of a telescope fixed to the bottom of the orbiter, looking straight down. Line arrays had been used in spy satellites and by the SPOT and Landsat Earth-viewing spacecraft, but never on a solar system mission. The technique, called "push-broom mode," is beautifully simple: Imagine the line of detectors as a broom sweeping smoothly and constantly along the surface of Mars. It builds up an image one horizontal row of pixels at a time, and the digital camera stays running all the time. The instrument's 12-megabyte storage buffer can hold enough data for a photograph of Martian real estate 19 miles long and 1.9 miles wide. Or it can hold smaller strips that add up to a length of 19 miles. When the buffer fills up, the data is sent to the spacecraft and radioed to Earth.

One great challenge with this approach is the speed at which the camera is scanning. To achieve its high resolution, the Mars Global Surveyor orbits at a relatively low altitude of 250 miles, about four times closer in than Viking did. At this height the spacecraft is zipping over the Martian surface at nearly 3,000 meters a second. That leaves only two-thousandths of a second to expose each 1.5-meter (five-foot) pixel before the broom pushes on.

Another closely related problem was detector noise. The camera's high focal ratio, the fleetingly short exposure times, and the dim light conspired to produce a very faint signal that could easily be drowned out by electronic noise generated by the CCDs themselves. For the Mars camera to work, the CCDs had to be 30 times quieter than the dectectors used in Voyager.

Malin and crew put the problem to a JPL engineer, James Janesick, who knew of a company in nearby Newport Beach that made very good, inexpensive, low-noise CCDs. "Jim swore up and down that they were producing something we weren't seeing from anybody else," says Ravine. He turned out to be right, and Malin ended up buying the detectors, which were indeed much better than Voyager's.

The next task was to reduce the need for power, and again the team turned outside the company, to a consultant


KEITH SKELTON

Mike Ravine (left) and Mike Caplinger (holding a model of the Mars Descent Imager) are two of the mainstays at Malin Space Science Systems. The company invents only when it has to, preferring to buy advanced technology off the shelf.

and electrical engineer named Chris Hansen. The camera and its data and storage system would have only 16 watts to use in churning out five million pixels a second. "We said, 'Give us a design for these requirements' and he did it," Ravine says. "It was pure engineering artistry."

Malin's team was perfectly happy to farm out this kind of work. "Much of our success is because we took advantage of the fact that the commercial world was spending orders of magnitude more money on research and development than NASA could ever afford to spend," says Ravine.

Soon Malin began to feel cramped in his lab space at Arizona State, and with the help of a $240,000 MacArthur grant, he left academia in 1990 to form Malin Space Science Systems, Inc. Mars Observer was launched in September 1992. By the time the spacecraft was approaching Mars almost a year later, the company had a staff of 12 and was on the verge of hiring another person.

Then disaster struck. The radio signal from the Mars Observer went dead just as it reached the planet, and the spacecraft was never heard from again.

Malin knew all along that spaceflight is risky, and he had prepared himself for disappointment by focusing on intermediate goals, such as building a company and designing the camera. But the other members of his group took it harder. Mike Caplinger, the company's senior scientist, wrote this caption for one of the few distant, low-resolution photos returned by Mars Observer: "After six years with the expectation of seeing spectacular color images of Mars—to have this be the best one is a bitter disappointment." Malin had to let go about half his staff.

Within two months, however, NASA was hatching a plan to fly five of the eight Mars Observer instruments on a new mission, to be called the Mars Global Surveyor. It was a foregone conclusion that the Mars Orbiter Camera—the third cheapest of all the instruments—would be among them. Spare parts from the original instrument were assembled at Caltech over a two-year period, and Malin's camera finally arrived in orbit around Mars in September 1997.

The plan was to circularize and lower the orbit over the course of several months by repeatedly dipping into the atmosphere (a process known as aerobraking) so that the Global Surveyor could get into a circular orbit close enough to map the surface. But problems with the solar panels delayed the start of mapping until last March. Having been burned once, Malin decided

to wait until the spacecraft was in the proper orbit before building up his staff. He was still able to take pictures during the long, slow circularization—it was an unexpected dividend—but at a much slower pace. This got him some flak from the 15 other scientists on the Global Surveyor imaging team, who depended on him for data but weren't getting it. Even NASA chewed him out for being too slow.

Malin felt injured. A perfectionist, he wanted to locate each picture precisely with reference to the Viking and Mariner 9 imagery before releasing it. But during aerobraking the camera track was hard to pinpoint because the flight controllers couldn't predict the orbits exactly. Sorting it all out was meticulous work. Malin had thought more members of the imaging team would come to visit his office and help with the job, but they didn't. The problem was partly funding, partly the fact that other missions were competing for the scientists' time. The situation improved, though, when the Surveyor's orbit was finally circularized last spring and Malin ramped up to a full staff.

The 15 employees of Malin Space Science Systems occupy a glassy, pristine building just north of San Diego, in La Jolla, California. The office seemed strangely quiet and empty the day I visited, considering that the Mars Global Surveyor was busily transmitting never-seen images of Mars from 54 million miles away. It's a far cry from the bustle and excitement during planetary encounters at JPL, but then this mission has a different character, since it will run continuously for nearly three years.

If the picture of rocks on the plains of Elysium is Malin's favorite Global Surveyor image so far, his least favorites are the ones NASA ordered him to take of the so-called Face on Mars. In the new, high-resolution views, what had looked like a face in the old Viking pictures turned into what scientists had always suspected it was: just a jumble of rocks and outcrops. According to Malin, it cost $400,000 to take the new pictures. There were other targets that could have been viewed on that same orbit, including volcanoes on Elysium that would not likely come into view again. "Does the government spend money on ghost research?" Malin asks. "Or looking for the Loch Ness monster? Or the lost continent of Atlantis? I think the Face was a kind of stupid thing to spend money on."

The targeting and documenting of much of the imagery has been done by Ken Edgett, a young planetary scientist from Arizona State, where Malin had been on his master's degree review committee. Edgett smiles a lot and talks in a slow, thoughtful, manner. Part of the pleasure he gets from his work is the almost instant gratification of using the Mars Orbiter Camera: It usually takes only about a day or a day and a half from choosing the target to getting the pictures back, a far cry from other planetary missions, where scientists sometimes can't get their imagery for months. Edgett finds this type of planetary science "very hands-on."

His targeting software is simple and straightforward—a global view of Mars showing the limits of the wide-angle camera view for each orbit, with the ground track for the high-resolution camera running down the center. All Edgett has to do is click on the target he wants, punch in an exposure time, and enter. Predictability makes everything a snap. The spacecraft's orbit and attitude never change, there's no instrument platform to be aimed, and the instruments are always on. For the most part, all the operator has to do is decide when to start and stop taking data.

Already these sharp, high-resolution pictures are changing scientific theories based on old, blurry images. One idea that has fallen by the wayside is that of a rainy Mars. In Viking photos, many of the dried-up Martian channels appear to have smaller and smaller "tributaries," suggesting an Earth-like drainage pattern—and therefore rainfall—in the planet's distant past. This dendritic pattern vanishes with the new camera's closer look. Instead, the channels photographed so far appear to have caved in following the sudden release of underground water—possibly due to vol-

This close-up of the Martian moon Phobos has a resolution of just over six feet per picture element (pixel). The spacecraft "slew" rate changed while the image was being taken, which distorted some of the craters.

The above close-up of a 1.8-mile-wide area reveals frost on the rim of a crater, even though it's summertime in the northern hemisphere of Mars. The layered cliff below, one of many in the vast system of canyons called Valles Marineris, is five to six miles high.

canic or hydrothermal activity melting permafrost, a phenomenon Malin had studied in Iceland.

Another idea that the close-up photos have challenged is that a large ocean once filled the lowlands in the northern hemisphere. In the mid-1980s, JPL planetary scientist Timothy Parker thought he saw evidence in the Viking imagery of two sets of shorelines, one for an ocean that would have filled the lowlands almost completely, and one for a smaller ocean in the middle of that basin.

Although another Global Surveyor instrument, the laser altimeter that measures the height of surface features, has returned some evidence in support of this theory, Malin and Edgett have found nothing resembling beaches in any of their imagery—no marine terraces, wave-cut cliffs, caves, bays, lagoons, or successive shorelines reflecting different sea levels. In one case, Edgett says, the "shoreline" turned out to be a contact where one type of surface rock abutted another.

Smooth material identified by the laser altimeter as a possible ocean basin may ultimately turn out to be a lava flow instead. Under high-resolution scrutiny, layered flows are appearing all over Mars. According to imaging team member Alfred McEwen of the University of Arizona's Lunar and Planetary Laboratory, even the walls of Valles Marineris—the 3,000-mile-long system of canyons near the Martian equator—have at least five vertical miles of layering, and probably more, because they extend below the valley floor. It's still a matter of controversy as to whether these layers formed due to volcanism or some sedimentary process. Either way, counting craters in the topmost layer of Valles Marineris allows scientists to estimate when the deposits were laid down: between 3.5 and 4 billion years ago.

Even while they study the new pictures, Malin's scientists and engineers are hard at work trying to make their cameras smaller, cheaper, and stingier with power. A second-generation camera is already on its way to Mars, on board both the Mars Climate Orbiter and the Mars Polar Lander, due to arrive this September and December, respectively. Two similar cameras will be placed on an orbiter-lander pair to be sent to Mars in 2001.

These second-generation cameras are small enough to hold in your hand and weigh only about a pound, half of which is electronics. The medium-angle lens is about two inches in diameter and four inches long. Lacking the high resolution of the Mars Orbiter Camera, it will transmit its data at just one-fifth the speed: a megabit a second.

The Climate Orbiter's Mars Color Imager, or MARCI, will have a wide-angle camera for studying the atmosphere, and mounted next to it a medium-angle camera for viewing the surface at resolutions of around 130 feet. Each will take color pictures with only one lens, and no filter wheel of the type Voyager and Viking used. The trick, according to Mike Caplinger, comes from going back to a square "area array" of CCD sensors. On top of the array are eight filter strips—for red, blue, green, and infrared light—laid out horizontally, perpendicular to the direction of orbital motion. The camera takes a picture every two seconds, which is the length of time it takes for the spacecraft to move along its ground track a distance equivalent to the width of a strip. The result is essentially the same picture taken at eight wavelengths, which can be superimposed to get a full-color image. (When I asked Caplinger who thought of this clever technique, he looked embarrassed and said he thought it might have been himself. This was a rare in-house breakthrough.)

The Polar Lander, which is due to set down on the Martian surface on December 3, will carry one of the company's most exciting cameras yet: a Mars Descent Imager to take pictures of the surface during the last minute and a half before touchdown. Malin sees it as the link between orbital photography and ground photography. The camera will snap 20 or so pictures on its way down, the first time this has been done since Apollo. Even though the lander will be swinging on a parachute, the 70-degree-angle lens is bound to capture the landing site in its field of view most of the time. There will be other pitfalls to overcome: vibrations when the descent rocket fires, exhaust from the rocket engines, and flying dust as the spacecraft nears the ground. To pro-

tect against the dust and exhaust, the camera will be aimed slightly to one side. Whatever images aren't fogged by dust or blurred by swinging and shaking will help scientists establish the context for pictures returned later from the ground.

Those surface images will be taken not by Malin but by Peter Smith and his team at the University of Arizona's Lunar and Planetary Laboratory, who also built the camera for the Mars Pathfinder. This group has a second camera on the mission—a tiny one on the lander's arm, which will be able to resolve an individual grain of sand in material scooped up by the arm.

The two teams are competitors. Indeed, they are each other's only competition outside of JPL. Smith, who is as easygoing and comradely as his colleague is crusty and independent, likes Malin, who submitted a losing proposal for the Pathfinder camera and served on the imaging team for the mission.

"We get along very well," says Smith. "He is a delight to work with. It's much easier to have competitors you don't like." Though NASA so far seems to be picking Malin's group for orbital imagery and Smith's for the landers, both scientists say the agency isn't trying to force them into niches. Rather, as each group gains more experience with its type of photography, its cameras become more economical.

Early afternoon on Mars: A slight wisp of cloud hangs over the crater of an extinct volcano. The Mars Global Surveyor is studying the thin Martian atmosphere as well as the surface geology, and returns a new global view of the planet each day.

Malin, Ravine, and Caplinger are already working on the third generation of imaging system, which would be as much as an order of magnitude smaller than the cameras on the 1998 and 2001 missions. Estimated weight: two to three ounces. To accomplish this, the team would shift from using CCDs, which have demanding electronic requirements, to newer devices called active pixel sensors. Producing a single image would no longer take 20 or so integrated circuits, as CCDs do. Instead, everything could be handled by a single chip. Among their other advantages, the new sensors use less power. "We are tracking their commercial development right now," says Caplinger.

High-performance cameras weighing less than two ounces would have a variety of uses, both in space and on the ground. They would be small and light enough to be used on a spacecraft for engineering observations as well as scientific ones. For example, they could be trained on solar arrays or antennas to help engineers on the ground identify problems. It would have been nice to have had such a tiny camera on board Galileo, which because of a balky high-gain antenna had to drastically cut back on its telemetry to Earth. Closer to home, it would be nice to have a camera right now on the Mars Global Surveyor, to help engineers solve the solar array glitch that set the mission so far behind in its mapping schedule.

At the moment, the future project that most excites Malin and company is an airplane to be called Kitty Hawk, which NASA wants to fly on a three-hour, 1,800-mile journey through the Valles Marineris in 2003, the centennial of the Wright brothers' first powered flight. Ravine feels that the future exploration of Mars has to include aircraft. "You can't explore the Valles Marineris with a rover," he says. "And the distances are too great. An airplane beats a balloon any day."

An airplane on Mars isn't a new idea. Malin in fact suggested one back in 1976. He's still interested, even with the low-end budget that's been proposed for the mission, and despite the possibility that much of the development work will be done at a NASA center rather than at universities or private companies. By planetary spacecraft standards, the cost of the flight will be dirt cheap: $40 million. "I'm not sure we can do it for that, but it's the only game in town," Malin says. "So I roll up my sleeves and say: 'What can we do for $40 million?' " Caplinger already knows. He'd cover the Mars airplane with ten of those little two-ounce cameras.

Remnants of

A LIGHTPLANE TOUR OF AVIATION'S

Glory

PAST

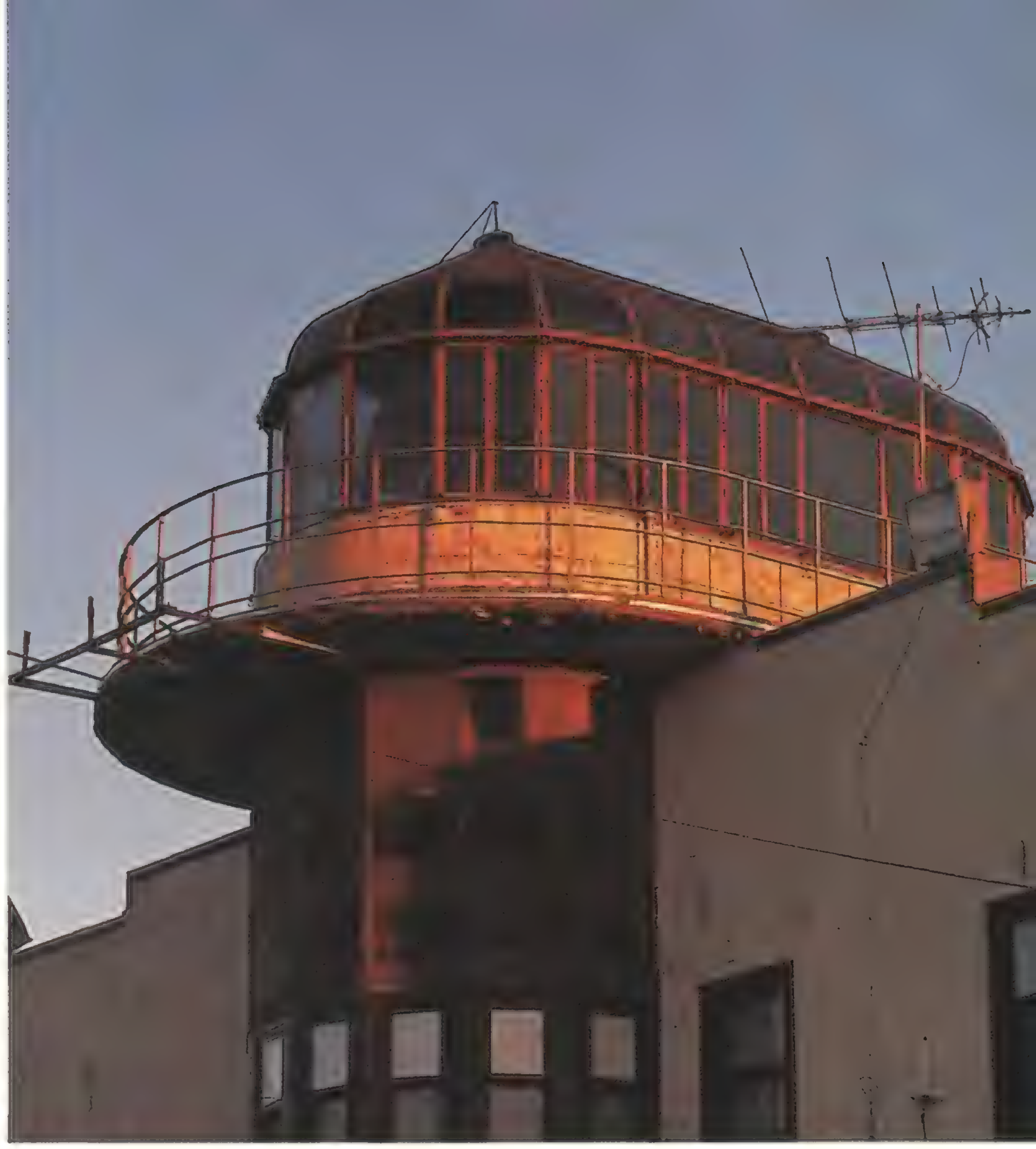
In the shadow of a 50-year-old control tower (right), this quiet Kingman, Arizona airfield was once the site of a U.S. Army Air Forces gunnery school, where thousands of heavy-bomber crewmen trained during World War II.

Years ago, a bunch of guys could get together, build something great like the Parthenon, and not worry about it being bulldozed for a K-Mart. Today? Fat chance. Today something new hardly reaches middle age before it's leveled for something newer. Sadly, very few icons from aviation's Golden Age will survive for future generations to enjoy.

STORY AND PHOTOGRAPHS BY RUSSELL MUNSON

Consider that the entire history of powered flight is less than a hundred years old, a mere flea on the tail of the drooling St. Bernard of time, yet most of the physical evidence of aviation's history has already disappeared. We're lucky the hallowed sands of Kitty Hawk didn't become a shopping center, as New York's Roosevelt Field did. You would think they could have preserved at least the strip of earth where Charles Lindbergh's *Spirit of St. Louis* rose that May morning in 1927.

As all of this rancor was welling up in me last summer, I decided to climb off the soapbox and into my Piper Super Cub to launch a meandering search for bits of aviation history that have managed to survive, either by getting overlooked, remaining useful, or being protected by people who care. What I hoped to find were quiet, lesser-known places where a visitor could stand in a hangar in which, say, a Boeing 80A waited for smartly dressed passengers bound for Chicago in 1932, or see a beacon that once guided Jack Knight with a load of mail through a pitch-black sky in 1925.



Living in New York City, I first looked in my own back yard. Newark International is neither quiet nor unknown, but nestled in the northeast part of the airport, far from the hustle of the new terminals across the field, stands Building 1. Two stories of blond brick accented with deep maroon masonry are visible through the grime of neglect. Perched on top, in the center of the south side facing the runways, is the most elegant control tower cab I have ever seen. It is shaped like the inverted wheel house of a dirigible, a contrast to the slab-sided polygonal tower of today. This capsule has sensuous curves and glass panes framed in metal, which during a clear sunrise glows like gold.

Newark Airport's original control tower cab (above) remains atop Building 1, the former main terminal. In 1951 Building 1 was a good place to watch the bustle of the nation's burgeoning airline industry (below). The cab can be seen at the center of the terminal.

PORT AUTHORITY OF NY AND NJ

Building 1 was once Newark's main terminal, dedicated in 1935 by none other than Amelia Earhart. A year later, it had become home to the nation's first air traffic control center. Directly below the tower, cars are parked on what was once part of a ramp spotted with DC-2s, Curtiss Condors, and an occasional Northrop Delta. In my mind it was like a movie set, a sound stage where a pilot like Ernest Gann, author of *Fate Is the Hunter*, had strolled to his American Airlines DC-2 bound for Cleveland. I imagined him standing right here smiling that Ernie grin, and I thought too of the lesser known but equally formidable airmen who had also taxied from this place to take a load of passengers across the country in a time when low-frequency radio was cutting-edge technology. How long ago was that? Sixty years or more? I wasn't there then, but Building 1 was, and it took me back.

Unfortunately, the future of old Number 1 is in doubt. Runway 4 Left is being extended, and the building may be too close. For the moment, it still provides office space to a handful of companies. With luck, those who want it preserved for a museum can hold off

the circling bulldozers until a solution is found.

The jigsaw spires of Manhattan were out of sight and miles behind me by the time my Super Cub was splitting the mountain air of the Alleghenies at a speed perhaps slightly in excess of 100 mph. Flying at an altitude that now and then exceeded that of the ridges, I wove through the curving, tree-covered ripples of Pennsylvania, past Williamsport, Lock Haven, and Bellefonte, taking in the beautiful farms and the laundry on the line, then watching the terrain gradually subside into smaller convulsions until it was smooth again over Ohio.

The former terminal at Ohio's Akron-Fulton airport, an Art Deco masterpiece designed by the late Akron architect Michel Konarski, was slated for demolition until it was rescued by a local businessman.

The unmistakable Goodyear Airdock at the Akron-Fulton airport was visible from 15 miles out. Arching more than 100 feet high and extending 900 feet in length, this is the largest of three hangars where Goodyear assembled such airships as the *Akron* and the *Macon*. In 1930, when construction began on this incredible building with its enormous clamshell doors, an influential contingent of the aviation industry was convinced that airships would be the primary vehicles of long-haul air travel. In fact, I was told, the location of this airport was chosen partly because the terrain forms a shallow bowl offering protection from the wind—an ideal spot for mooring airships. Imagine three aerial whales moored to the masts in the field by the Airdock. As the wind changed direction, they would pivot around the masts on asphalt circles (now overgrown).

The gargantuan 1930s Goodyear Airdock, a hangar once used to assemble airships, dwarfs the author's Super Cub.

An architectural treasure of a different style is on the north side of the airport, across the field from the Airdock. This 1931 Art Deco building—the former terminal—is one of the few gems of its type left in the country. The aviation spirit and the optimism of the era are suggested in the building's form and detailing. Beautiful terra-cotta relief figures of the hemispheres and winged creatures decorate the facade. This is a fabulous minor masterpiece designed by the late Akron architect Michel Konarski. Even so, an airport master plan a decade ago called for it to be destroyed. Fortunately, there were enough outraged citizens in Akron to cause an uproar. Some grumbling still goes on, partly because the beautiful control tower cab on top was removed, but the outcome was a compromise between commerce and preservation that saved the building.

John Piscitelli, an Akron restaurateur, bought the building from the city for a nominal sum to house a new restaurant, the Piscitelli Cafe, which he opened in 1993. As part of the bargain, Piscitelli agreed to restore the structure to its former glory. He told me that he invested more than a million dollars in the project, and it shows. Not only was the building saved and restored, but it is now a fine restaurant that brings townsfolk in to enjoy the airport—a win-win for aviation.

My morning flight from Akron to Bryan, Ohio, an hour and three quarters in length, took me over the green farms and small towns that mark the eastern boundary of the Midwest, that great, nourishing stretch of earth from Ohio through Kansas. Bryan lies southwest of Toledo, not far from the Indiana border.

Because of its location, midway between Cleveland and Chicago, Bryan was a stop on the early airmail route. The town cleared a

BRYAN POST OFFICE

In 1918 mailplanes such as this de Havilland DH-4 landed in Bryan, Ohio, to refuel on the early airmail route between Cleveland and Chicago. Today the airfield's hangar stands vacant (top; nine months after the author took this photograph, the hangar's roof caved in).

field to its north, where the first mailplane landed on September 9, 1918. By December 11, a modest hangar had been built. Fortunately, it remains—on North Main Street, bordering the vacant field that was once the airport.

John Speer and LeRoy Feather, two of Bryan's aviation enthusiasts, took me there and filled me in on the hangar's varied history. After the airport moved south of town, the building was used by a succession of businesses, most recently a glass company. Sliding hangar doors big enough to accommodate a de Havilland DH-4 were removed long ago and replaced with bricks and smaller doors.

Today the building is vacant. The owner is willing to sell for a goodly amount, but no one has come up with the cash. Local pilots and others proud of Bryan's place in aviation history, such as longtime unofficial Bryan historian Bud Williams, would like to see the building donated or somehow acquired, restored, and preserved. This must be one of the oldest remaining hangars in the country, and the only tangible link to Bryan's historic place on the transcontinental airmail route. After surviving this long, it surely deserves to be saved forever, and a way must be

F.W. KENT

Boeing Air Transport, which later became United Air Lines, established a base in Iowa City in 1930 (above). Today the hangar is used for airplane storage (top).

found. The surrounding area, however, is being developed.

As long as I was on the airmail route, I decided to continue westward, bypassing Chicago to land at Iowa City, Iowa, once the only mail stop between Omaha and Chicago. Boeing Air Transport—later United Air Lines—built a hangar here in 1930. The airline pulled out in 1959, but the hangar is still in use. My late father flew United Boeing 247s through here in 1938, and he must have been in this hangar 60 years ago.

Denis Gordon, a local pilot, happened by the airport office as I was preparing to leave. After he learned what I was doing, he asked if I would like to see some photographs from the airmail days. (He probably figured from the Super Cub that I was in no hurry.)

In his hangar office was a wonderful collection of prints given to him by the late F.W. Kent, a commercial photographer in Iowa City who liked to hang around the airport, taking photographs that documented historically significant aspects of early aviation. Before it faces possible demolition, the old hangar should be moved and converted into a museum, which could house Kent's photographs.

A few years later, Boeing Air Transport built a nearly identical hangar in North Platte, Nebraska, which now houses Trego Dugan Aviation. The most noteworthy aviation artifact in North Platte, however, is a man named Louie Drost.

Louis C. Drost Jr. was born on December 14, 1901, almost two years to the day before the Wright brothers first flew a powered airplane. His family moved from Iowa to North Platte in 1904. Once airplanes and airports were invented, Drost was drawn to them, never as a pilot but as a starry-eyed teenager hanging around the North Platte flying field. Airmail pilots were heroes. When they went to the Palace Cafe for coffee, everyone wanted to sit next to them.

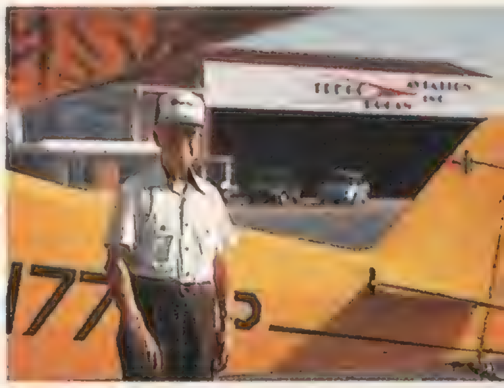
As Drost recalls, he went to work for the postal service around 1920 or '21 as a field and mail clerk for $100 per month. He stayed on until 1927, when the federal government signed over the San Francisco-Chicago route to Boeing Air Transport. During that span he drove mail between the airport and train station, set bonfires on the airstrip for the airmail pilots to land between at night, got weather reports by telephone from towns along the route, and helped recover aircraft that had made emergency landings. "Those Liberty engines stripped gears a lot," he told me, and that would force aircraft into the nearest field, or, as happened to Jack Knight, the North Platte River. Drost rode in the mail bins of DH-4s and helped install the cables when North Platte became the nation's first airport with electrical lighting.

It was a privilege to listen to Drost for the two hours of memories he so generously offered. It is also reassuring to find people like Doyle Werner and Hollis Branting of the North Platte Historical Society, both of whom donate their time to ensure that memories as well as flightsuits, helmets, and other objects of the era are not lost.

From North Platte, I flew along the old airmail route to Cheyenne, Rawlins, and Rock Springs, Wyoming, then up to Jackson and through Teton Pass into Idaho. I fly this route almost every summer. The complex texture of this astounding terrain is revealed to those fortunate enough to see it from a low-flying aircraft.

My next artifact destination was Kingman, Arizona, but first I wanted to search part of the airmail route between Salt Lake City, Utah, and Elko, Nevada, with a friend, Steve Wolper, in his Cessna 206. I had photocopies of maps from old aviation books that showed those airways that were lighted. Beginning around 1923, after night flying became accepted but before low-frequency radio ranges were established, the federal government established a network of airways lighted by beacons. Every 10 miles or so, depending on terrain, a tower was erected with a powerful beacon on top. They

Louie Drost, 96 (below), worked for the postal service in the 1920s as an airmail clerk based in North Platte, Nebraska. Drost helped recover this de Havilland DH-4 mailplane, which had made a forced landing in the North Platte River (bottom). The pilot, Jack Knight, told Drost that he landed near the river bank "to keep from getting my feet wet."



LOUIS C. DROST JR.

Right: After World War II, thousands of aircraft ended up in Kingman, Arizona, on their way to auction or the scrap heap. Kingman still serves as a boneyard, likely the final resting place for the decommissioned airliner at bottom.

The lamp is gone, but the tower of an airway beacon still stands at Deeth, Nevada (below). In the 1920s, the powerful lights were a welcome sight to pilots flying mail runs through the night.

were a godsend to pilots on a dark night. By the late 1950s, almost all were decommissioned and removed. Yet Ted McBride, a charter pilot in Elko, Nevada, told me he had seen a couple of towers still standing along the route, although the lights had been removed. "We still used them in the '50s," he said. "They were great. On a clear night you could see three or four ahead. I wish we still had them."

My old charts showed a beacon at Deeth, Nevada, between Elko and Wells. Deeth is such a small town that finding it was almost harder than spotting the tower, which we found late in the day, standing by some trees near a ranchhouse. Steve and I circled several times, imagining what it must have been like to fly by beacon light through this desolate country.

The trip south through Wells, Ely, and Boulder City, Nevada, is through valleys—some broad and straight, others narrow and winding—framed by powerful mountains. Nearing Las Vegas, pilots must be aware of U.S. Air Force training areas, but from Hoover Dam, which creates Lake Mead, it is a short, beautiful trip down the Colorado River to Bullhead City, which is just across the state line in Arizona. Make a left there and the highway takes you across a couple of ridges into Kingman. (Of course you could always fly a more direct route, but it wouldn't be as much fun.)

Kingman was a vast U.S. Army Air Forces gunnery school that trained thousands of

W.T. LARKINS/COURTESY THE MOJAVE MUSEUM

heavy-bomber crews during World War II. The control tower, looking like a pod from outer space on spindly legs, is in fine condition. The cab is empty, but the structure has been maintained. Control towers of this design are extremely rare, and the aviation history buffs at Kingman are determined that it will survive.

The Mojave Museum of History and Arts in Kingman and, amazingly, the charming airport cafe both have information, pictures, and some hardware from Kingman's aviation heritage. To date there is no central, funded repository for all of this. It remains scattered, but at least cherished.

My time was running short. One hour in an airline jet is the equivalent of one day in a Super Cub, and I was 2,000 miles from home. There was one more place I wanted to investigate, however.

In 1931, when Transcontinental & Western Air was a mere pup, the airline built a headquarters and maintenance building at what is now Kansas City Downtown Airport in Missouri. It is alive and well, I'm happy to report, occupied now by a Beechcraft dealer. TWA pioneer Jack Frye had the corner office on the second floor, overlooking the field. Howard Hughes, one-time owner of TWA, didn't have an office here, but he haunted the halls from time to time (and probably still does).

This part of the world has a special place in my heart, because it was here that a dream came true. Twenty miles up the Missouri River, northwest of Downtown Airport, I learned to fly, in a Super Cub

TWA

A Beechcraft dealership now occupies the Transcontinental & Western Air headquarters and maintenance facility built in Kansas City, Missouri, in 1931 (left). TWA founder Jack Frye worked out of the corner office on the second floor (above).

owned by the Fort Leavenworth Army Flying Club. Since the Cub didn't have the latest navigation equipment, I had to rent a properly equipped Cessna 150 from Downtown Airport for my flight test. The big event took place at the Federal Aviation Administration district office at Fairfax Airport, directly across the river from Kansas City Downtown. I'm glad to say I passed, but Fairfax Airport, with its wonderful Art Deco terminal, is gone.

For old time's sake I made a low pass down the runway at Fort Leavenworth on my way home. It hasn't changed all that much since 1962. I recalled beautiful clear nights when I practiced night flying in the club Navion. I would fly from Leavenworth to Atchison, Atchison to St. Joseph, down to Fairfax gliding in over the river, then back to Leavenworth. On moonlit nights I turned off all the instrument lights and just cruised alone in the sky with my thoughts. Those were magical flights.

By the time I was back home in New York, I felt much better about the future of aviation's past. At every stop, I had met people who were trying hard to keep what remains safe for the future. I was especially impressed that the airport managers and staff I talked to—Jim Malyj at Akron-Fulton, Ron O'Neil at Iowa City, Kent Penny at North Platte, Bob Najaka at Kingman, and Ed Noyallis at Kansas City Downtown—knew so much about their airport's history and wanted to preserve it. I guess that's why they are still hanging around airports like we did when we were kids.

THE COFFEE ROYAL SCANDAL

A 1929 chain of events in the Australian Outback illustrates the dark side of aviation record attempts.

by Lise Pyles

Australia's Outback, or "Red Heart," is not for the easily defeated. Shadeless plains of rust-colored sand and stunted scrub stretch to the horizon. Depending on the road and season, hours or days might pass before the traveler sees another car, and the infrequent road signs bear dismaying messages. "NEXT PETROL OR PHONE 287 KMS [178 miles]" is a memorable example, as is graffiti reading simply "TURN BACK."

In the early days of flight, Australians were naturally eager to see the desolate million-square-mile expanse conquered by airplane. The aviators credited with the first flight across Australia were H.N. Wrigley and A.W. Murphy, who in 1919 made the journey in 19 hops over 26 days. But even a decade later, cross-country flights had not become routine. One Australian who attempted the journey was Charles Kingsford Smith—"Smithy," Australians called him. A former World War I pilot and, briefly, a Hollywood stunt flier, he had strong features and an easy smile, and he seemed able to overcome every obstacle. In 1928 he made the world's first trans-Pacific flight. But his attempt to cross the Outback the following year ended in a calamity that caused his adoring public to turn on him. Newspapers skewered the nation's number-one hero, fan letters gave way to hate mail, and where women once blew kisses and men elbowed through crowds to shake his hand, now they jeered him in the street.

Seventy years later, the incident retains a prominent place in Australia's air lore. Pilots who must fly across the Outback still contemplate the story's harsh details, and still mull over who and what were to blame for the disastrous turn of events.

On March 30, 1929, Smithy, copilot Charles Ulm, navigator H. A. Litchfield, and radio operator T.H. McWilliams boarded Smith's Fokker F-VII tri-motor in the eastern Australian city of Richmond and took off for Wyndham, in the north. From Wyndham, the crew would continue on to England. The purpose of the latter leg was two-fold. In England, Smithy and Ulm would purchase airplanes for an airline they were starting, Australian National Airways; in addition, the trip would count as the first leg of what Smithy hoped would be a historic feat: the first circumnavigation of the world in the same airplane.

Shortly after takeoff, Litchfield passed a message up to the cockpit (because of the din of the three Wright Whirlwind engines, Smithy and Ulm had stuffed cotton in their ears). The message read: "Long wave aerial gone. Shall we return?"

From his place in the cockpit, Litchfield had accidentally bumped a button that had unreeled a copper wire aerial out behind the aircraft. Normally the spool contained enough wire for three aerials, so if one should break as it trailed behind the aircraft, a new length could be released. In this case though, the entire length had unfurled, then snapped off the spool. The crew would no longer be able to receive transmissions.

After pencilling a few brief words to each other, Smithy and Ulm decided to press on. Their airplane, which was officially named the *Southern Cross* but which Smithy was fond of calling "the old bus," was, after all, in top condition. Smithy admired its huge wing: The 72-foot wingspan made the airplane one of the largest of its time, and Anthony Fokker's innovative design—the wing's chord reached a maximum of 33 inches—provided generous lift. Smithy also

LISE PYLES

When another aircraft was reported lost during a cross-country flight, Keith Anderson took off in pursuit in his Westland Widgeon III, the *Kookaburra*, only to end up in desperate straits himself. Were his actions selfless or merely reckless?

took pride in the craft's fuel capacity; in addition to the huge tank in the fuselage, he'd installed four tanks in the wing and a fifth under the pilot's seat, for a total capacity of 1,300 gallons. This morning the old bus was loaded with 750 gallons, which seemed like more than enough. The crew felt confident about continuing on.

After 15 hours, the blue skies that had accompanied them halfway across the Outback began to dissolve into churning red dust, lightning, and rain. Australia's wet season should have been over, but torrents of water now lacquered the *Southern Cross*, making it impossible for Litchfield to reckon by the stars. They were lost.

By morning the clouds thinned to reveal a sobering view. "I have never seen such an inhospitable terrain of ravines, roaring torrents, cliffs, heavy timber, and an entire absence of any habitation," Smithy wrote later in his memoirs. They were over the wild land of rocky gorges known as the Kimberleys. Later, they spotted a cluster of missionaries' huts, known as the Drysdale Mission. They wrote notes asking for help in finding Wyndham and, after weighting the notes, dropped them over the huts. But the missionaries missed the messages and thought the crew was only looking for the nearest landing spot. They had natives point them off

to the southwest, instead of the southeast, where Wyndham lay.

The crew later flew over a second mission station, Port George. The missionaries there did get the men's notes, and they used bedsheets to form the number "250" and pointed toward Wyndham, by now well behind the *Southern Cross*.

They flew toward Wyndham for 20 minutes, but then realized that they hardly had fuel for 25 miles, much less 250. With few options left, Smithy spied a mudflat near a river. It was the only spot clear enough to land on. The Fokker put down in over a foot of mud.

"Kingsford Smith Missing"

News reports of the crew's disappearance chilled the nation. A citizens' committee was formed and took donations from the public to finance a search party. Three commercial airplanes plus a privately owned DH-61 Giant Moth formed the front ranks of the search, followed by several Royal Australian Air Force DH-9A biplanes. Though some private pilots joined the effort, the search committee discouraged this. The Outback's sun-scorched Tanami Desert was no place for solitary single-engine mavericks.

One man disagreed. After several days had passed without word from the *Southern Cross*, pilot Keith Anderson entered the search. Anderson and Smithy had been partners and friends in years past, long before Smithy's 1928 trans-Pacific flight. They'd met when they both flew for West Australia Airways, later started a trucking business together, then flew charter flights in a pair of Bristol Tourers.

Throughout all these ventures, Anderson and Smithy had planned to cross the Pacific together. But then Charles Ulm joined the team, initially offering his services as business manager, and Anderson felt himself losing ground as Smithy's partner. In 1927 the three had traveled to the United States in search of an airplane for the flight, but even though it was Anderson who suggested the name *Southern Cross* for the Fokker F-VII that Smithy selected, it was already evident that Smithy's new

During his crossing of the Outback (dashed line), Anderson had little guidance: a few pages from an atlas, a railway map, and a depiction of some of the area's ranches. His predicament dramatized the need to survey Australia's million square miles of mostly featureless desert.

friend Ulm, not Anderson, would sit in its copilot seat. For a while Anderson reluctantly performed what amounted to stagehand duties for the team. Then he quit, and sailed home alone.

Australian pilot and aviation historian Dick Smith (no relation to Smithy) researched the careers of Smithy and Anderson for the book *Kookaburra*, written by Pedr Davis (Lansdowne Press, 1980). When asked to describe Anderson, Smith sighs. "Oh, poor Anderson. It's sad. He was a born loser." A passage in the book expands the point: "A brilliant and determined pilot, Anderson was fearless, stubborn, dedicated and hard-working. He also possessed that indefinable trait which separates losers from winners. Fate seemed to keep permanent watch on his movements, making sure that his decisions proved wrong and his best endeavours were frustrated by bad luck."

In June 1928, Smithy and Ulm flew from San Francisco to Brisbane, completing the first aerial Pacific crossing and arriving home heroes. Anderson—broke, no doubt jealous, and probably pressured by his fiancée's lawyer father, sued Smithy and Ulm for the money he'd spent on the team effort. Anderson lost, but Smithy offered him a monetary gift anyway. The friendship seemed to be restored, and with the money Anderson bought a Westland Widgeon III he named *Kookaburra*, a variety of Australian bird.

The Widgeon, a high-wing monoplane, was considered an advanced design. Its wings were supported by steel struts rather than the wire rigging more commonly used then, and were hinged to fold back for storage. A 24-gallon fuel tank was standard, but Anderson fitted the small airplane with additional tanks, more than quadrupling its capacity to 112 gallons, because he planned to pursue light-aircraft records on his own.

For several days Anderson had listened to the search parties' radio reports. Based on the locations of the two clusters of missionaries that had reported seeing Smithy's airplane, he felt that the searchers were looking too far

north. Recruiting H.S. (Bobby) Hitchcock, another Smithy friend, as mechanic, he decided to embark on a search party of his own.

Before taking off, the two had to fix a loose tappet, or valve push rod, procure a compass, and get it calibrated. That process, known as swinging the compass, is accomplished by aligning the airplane's nose with paint marks on the airfield's ramp that correspond to the points of a compass, then adjusting the airplane's compass accordingly. Ideally the airplane's compass is calibrated to all 16 compass points, but the swinging stations at many fields have fewer points, and Anderson, in a hurry to calibrate the second-hand compass Hitchcock had procured, may not have calibrated beyond north. Finally, they took off from Richmond.

On April 9, the two reached the dusty town of Alice Springs, at the Outback's center. Stan Cawood, then 21, met Anderson and Hitchcock that night. Seventy years later, Cawood recalls, "They stayed the night in Alice. My father was the area's administrator [governor] and had arranged accommodations for Anderson and Hitchcock, as a gesture toward helping."

Cawood talked with the men that evening. "Hitchcock was essentially quiet—an engineer whose interest was isolated to his home and airplane engineering. Anderson had had a bit more experience and had traveled a lot more. He was quite outgoing and confident. His talk was full of his plans to find Smithy and what a wonderful meeting it was going to be. He did talk about a bit of compass trouble, but that he could overcome it somehow."

NATIONAL LIBRARY OF AUSTRALIA

Anderson (right) and navigator H.S. Hitchcock at Richmond, just prior to takeoff. On that last flight, Anderson was clearly pushing the envelope: When they departed, their airplane was about 400 pounds overweight.

At dawn the next morning, the pilot and mechanic left the hotel. Cawood accompanied the two to their airplane and gave them a pastoral lease map of the area, which showed only cattle station owners' own drawings of the size, shape, and location of their ranches. Cawood also helped the two refuel. "We tried to get them to put a four-gallon tin of water in," Cawood recalls today, "but they said it wasn't water they wanted, they wanted more fuel." They took off with less than a gallon of water and one day's worth of food.

As most area pilots did, Anderson followed the wires of the Overland Telegraph line north, but then, to save 90 minutes of flying time, he veered west. He intended to pick up the line later, but seven hours into the flight and off course, the tappet problem again caused the engine's no. 2 cylinder to cut out. He was forced to land.

Anderson put down in a small clearing amid coarse scrub. Hitchcock made the repairs (when the engine was found later it was declared to be "functioning perfectly"), but the men had no axe for clearing the tough vegetation for a runway. It was later discovered that the two had tried to clear the brush using a penknife and bare hands. They attempted at least five takeoffs, but their makeshift runway was too short and the powdery soil too soft, and one tire and a spare were speared by the thorns of a turpentine bush.

Anderson chronicled their days by making notations on the doped fabric of *Kookaburra*'s tail. Rising above what must have been unspeakable anguish, his entries remained, to the end, calm statements of fact. "No take-off able to be attempted since April 11th, due to increased debility from thirst, heat, flies and dust," read one. By April 12 he reported having no liquid to drink except a mixture of "urine, petrol, oil, and

CHROME COLLECTION, NATL. LIBR. OF AUSTRALIA

Before the *Kookaburra* tragedy damaged his reputation, Charles Kingsford Smith won fans throughout Australia by performing aerial feats in his Fokker F-VII, which Anderson had named the *Southern Cross*.

methylated [spirits] from the compass." That was the last note he made.

"At least we have Coffee Royal"

Approximately 400 miles away, Smithy and crew were passing the time by slapping mosquitoes and lighting signal fires. They had a little food but not much: a few sandwiches and some baby food meant for delivery at Wyndham. After these were gone, their diet deteriorated to beans and muddy snails. They did have some coffee, which they spiked with brandy. According to one account, as they sat contemplating their situation, Smithy quipped, "We may be lost, mates, but at least we have Coffee Royal." They dubbed their new home of black muddy grounds "Coffee Royal" as well.

The crew also labored over the *Southern Cross*' transmitter. Normally powered by a wind-driven generator, it was now no longer operable. The men did manage to fix the receiver by rigging up a makeshift aerial, so they were able to listen to the search efforts that were under way.

On April 10, Smithy and his crew, as well as the rest of Australia, learned that the *Kookaburra* had failed to make Wyndham. Later, Smithy would write, "I well remember when the news trickled through on our receiving set that our first thought was: 'Let us hope that poor Andy has landed near water,' for we were very familiar with that forbidding stretch of mulga [a scrubby tree]

SAM HOOD COLLECTION, STATE LIBRARY OF NEW SOUTH WALES

When the *Canberra*, a DH-61 Giant Moth, returned with members of the *Southern Cross* crew, a joyous crowd was on hand to cheer them. But the public's attitude toward Smithy and his team mates soon soured.

country to the west of the Overland Telegraph line."

Two days later, the crew of the privately owned DH-61 Giant Moth spotted the *Southern Cross*. They dropped supplies (including cigarettes, after seeing "CIGS" written in the mud). The next day, a party of newspaper journalists was able to land on the mudflat (mostly dry by then) and visit the crew. Smithy's crew had to remain at Coffee Royal for another six days until fuel for the *Southern Cross* was delivered, but on April 18, they were able to fly their airplane to the airfield at nearby Derby. Newspapers trumpeted the news. The *Northern Territory Standard* declared "RESCUED IN THE NICK OF TIME."

Searchers now turned their attention to finding the *Kookaburra*. As days passed, Smithy recovered and prepared to join the search. Then on April 21 a pilot in a DH-50J biplane operated by Queensland and Northern Territory Aerial Services Ltd. (now Qantas) spotted the *Kookaburra*.

Smith insisted on overflying the site himself. Horrified, he spotted Hitchcock's lifeless form. In the slim hope that Anderson could somehow still be alive, he dropped supplies over the site. A ground party later discovered Anderson's body 400 yards from Hitchcock's. The searchers buried the two there.

After three weeks of misfortune, the deaths of Anderson and Hitchcock sparked grief and anger among the public. Newspapers began to blame Smithy, feeding a rumor that the whole incident had been a publicity stunt gone horribly wrong. The papers picked sides for and against: One ran an article headlined "Searchlight, Not Limelight" imploring Smithy to explain his lengthy disappearance fully and answer a list of questions.

Crowds who had formerly adored Smithy as an Aussie "battler" now bestowed that affectionate tribute on the two men who had given their lives for their mates. As for Kingsford Smith, he and even his fiancée received jeers and hate mail, according to *Smithy*, a recently published biography by Ian Mackersey. Besides the damage from the hoax rumor, Smithy's blithe Coffee Royal remark now seemed callous, as though he'd been happy to relax and enjoy his brandy while friends died to save him. The whole catastrophe became known as "the Coffee Royal affair," and it set off a reaction that Australians call "the tall poppy syndrome"—a general disdain for someone who rises too tall and needs cutting down. Smithy was a prime target for this collective sentiment.

Prime Minister Stanley Bruce ordered an inquiry to be conducted by a three-person Air Inquiry Committee, appointed in accordance with the Commonwealth of Australia's Air Navigation Regulations. The committee was told to examine both forced landings, as well as related air safety issues. On June 14, 1929, the committee issued its final report, based on the testimony of 74 witnesses.

Of all its terse findings, none was so important to Smithy's reputation as the verdict on the hoax allegations. The committee found no evidence of a hoax. Still, its report dwelled on several errors the members felt the *Southern Cross* crew had made:

• Not converting their receiver into a transmitter after they had landed. Radio operator McWilliams said he had rejected the idea because the conversion could have made the entire receiver unusable. And today, Perry Morey, a former pilot and an aviation historian in Alice Springs, notes: "The receiver's batteries would have been drained at a fast rate if used as a transmitter."

• Not using their 18 gallons of oil to produce signal smoke. Smithy had testified that black oil smoke wouldn't have been visible against the mud, since even the white smoke given off by the leaf fires they'd set had been overlooked by search airplanes. Years later, Dick Smith investigated this point by visiting Coffee Royal and arranging for two fires to be set—one with green leaves, as Smithy's crew had used, the other with oil—while he overflew the area and videotaped the results. He noted that Smithy was right: The white smoke's visibility did exceed that of the oil smoke, and even so, it reached only a little more than 500 yards.

• Not returning after losing the aerial. Ulm claimed that the radio was unusable anyway, due to engine noise. The committee disproved this, using records from previous flights. Smithy's response isn't noted in the inquiry report, but Dick Smith comments: "I wouldn't have turned back either. Wet season was over and they expected good weather."

Jim Thomas is an Alice Springs pilot

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The Australian government arranged for a six-wheel Thornycroft truck to retrieve Anderson and Hitchcock from the makeshift graves initially dug for them. The expedition crew also folded up the *Kookaburra*'s wings so they would not be damaged if a strong desert wind toppled the craft.

who has flown the bush many times, and when asked what he'd do if he were in Smithy's place and he had lost a radio, he pauses. "I have to admit that I've been in those circumstances and I did the same thing," he finally says. "I was flying an officer down to the opening ceremony of Connellan Airport at Ayers Rock and I had a radio failure upon takeoff from Alice Springs. I kept going when you're not supposed to, out of a desire to be part of the opening ceremony and not miss out."

• Not taking a better radio and more tools, not checking rations, and not checking weather reports. Despite the committee's criticism, Australia's Air Navigation Act had never defined the equipment and checks it considered mandatory. Smithy was also severely criticized for not awaiting updated weather information, relying instead on reports 24 hours old. But Sam Calder, a retired bush pilot who flew in the 1930s, understands the somewhat cavalier attitude toward weather reports, at least over the Outback. "The weather forecast out of Alice Springs was 'SE 15–20, clear skies changing to NE winds later in the day'—same every day," he recalls. "There really were no forecasts back then. If a dust storm came in, well, what happened, happened."

Was Smithy cocky about such things as weather reports? According to the inquiry transcripts, as quoted in the biography *Smithy*, the pilot stated flatly, "We were in the position of pioneers, and pioneers have to take risks. We don't pretend to be supermen, and we know we are not."

The committee next examined the *Kookaburra*'s forced landing. Here, the report's tone was, understandably, far less critical: "The Committee can only conclude that Lieutenant Anderson was so anxious to start on the search for his old comrades and friends, and so anxious to carry every possible gallon of petrol, that he would not wait to have his compass properly tested and would not carry an extra pound of rations or tools, deliberately taking the risks of any accident."

But what about those risks? Was Anderson reckless or merely luckless?

• Poor compass swinging. The committee criticized Anderson's calibration as inadequate. Bush pilot Sam Calder agrees, pointing out that in the Tanami, an accurate compass is critical. For example, he describes "a distance of around 125 miles of just a series of small sand hills, with no road or other features. Finally you'd come across open salt pans and lagoons, but you had to hit them pretty well bang on. You had to keep a close eye, flying by the compass all the time."

Even without a reliable compass, says Dick Smith, Anderson would have been all right if he'd stuck to the telegraph line. "But he wanted to save time," the researcher says. "I think he really wanted to find Smith first and gain a bit of fame for himself."

• No axe. Had the men brought along an axe, they could have cleared a longer runway for themselves. Perry Morey says he understands Anderson's omission: "Those little airplanes didn't need much of a clearing to get down and off again," he says.

• Little water. "Just a gallon of water would be 10 pounds, plus the weight of the container, another two or three pounds," says Morey. As it was, when the *Kookaburra* lumbered off from Richmond with its fuel tanks engorged, it was about 400 pounds overweight.

• Engine problems. In his book *The Failure of Triumph* (posthumously published in 1992), Australian pilot and airline pioneer E.J. Connellan wrote: "The Cirrus II [which powered the *Kookaburra*] was a lousy engine." Referring to the tappet problems that kept plaguing Anderson, he added bluntly: "This caused the death of Hitchcock and Anderson...."

• Poor maps. By all accounts, the maps found in the *Kookaburra*—four pages from an atlas, a railway map, and the pastoral lease map Cawood had provided—were poor.

Beyond the postmortem of the two forced landings (plus an incident in which another search airplane crashed with no injuries), the inquiry committee examined what could be improved for air safety. It recommended zoning Australia into "settled areas, unsettled areas, and recognized air routes," and that within designated zones, certain procedures, communication equipment, and emergency supplies be mandatory. The report also called for more timely weather reports, additional bases with equipment for compass swinging, and better maps.

Easier said than done. Still, the incident did trigger a few immediate changes. The tragedy so moved an Australian named Don Mackay that the following year he began surveying the Tanami at his own expense. And Australia's Connellan airline began requiring its pilots to carry axes.

Two months after the bodies of Anderson and Hitchcock were discovered and buried, they were exhumed and brought back for proper interment. Anderson, who had served as a pilot during World War I, received full military honors, and mourners lined the streets

by the thousands. Hitchcock, in accordance with his family's wishes, was buried privately.

The following year Smithy again made it into record books, this time for the first circumnavigation of the globe in a single aircraft. Even then he felt dogged by the specter of Coffee Royal. In 1932 he wrote, "These rumors [that the catastrophe was the result of a failed stunt] spread throughout Australia, and I believe linger even now." In 1935, flying a Lockheed Altair he'd named *Lady Southern Cross*, he disappeared over the Bay of Bengal, off India.

These days, Charles Kingsford Smith's reputation as a great aviator is again well celebrated, while Keith Anderson has receded into relative obscurity, with little beyond that sad diary and the remains of the *Kookaburra* (see *"Kookaburra* Revisited," below) to mark his place in history. Most people in Australia can't quite recall his name.

Nearly all historians agree that there was never any publicity stunt, but at the *Kookaburra* Memorial and elsewhere, Perry Morey still encounters people who want to hear about "that hoax." While the tale is most often remembered for the wrong reasons, it retains its poignancy for the right ones—as an illustration of the risks of pioneer aviation, the lengths to which friends will go for each other, and the folly of rushing headlong and headstrong into the red desert heart of Australia.


The Daily Guardian

GRIM ENDING TO SEARCH FOR KEITH ANDERSON

KOOKABURRA DISCOVERED BY Q.A.N.T.A.S. PLANE

"LYING IN PATCH OF BURNT GROUND . . . APPARENTLY DEAD BODY, BELIEVED TO BE ANDERSON, BENEATH WING . . . MACHINE UNHURT . . ."

BUT NOTHING SEEN OF HITCHCOCK

LOCATION: NORTHERN TERRITORY, BETWEEN POWELL'S CREEK AND WAVE HILL, IN DREADFUL COUNTRY

GRASS AND SCRUB BLAZED TO BRING RESCUE

SMILING, SHE SAW HIM GO

IS IT KEITH LYING DEAD?

ONE FOR RESCUE AND ONE WITH PLANE

PERHAPS A SMASH

HUGE TRACT OF DESERT

KOOKABURRA'S FINDER KNOWS COUNTRY

LOOKED FOR GOLD

FIANCEE BRAVE UP TO THE LAST

BRAIN'S OWN STORY

HITCHCOCK NOT SEEN

WHERE KOOKABURRA LIES

CROSS RECALLED

BROKEN BY GRIEF

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Australia's newspapers made no pretense of serving as detached chroniclers. The coverage in this example is fairly temperate; a later report, by contrast, was headlined "Vile attempt to blame [the] dead," while another story led with "Dead... dead... dead...that lonely body under the plane wing..."

Kookaburra Revisited

When the first search party reached the site where the *Kookaburra* had landed, the members didn't stay long. They hastily inspected the aircraft, buried Keith Anderson and Bobby Hitchcock where they lay, and left.

A second expedition arrived two months later. Designated the Thornycroft Expedition for the six-wheel Thornycroft truck the group traveled in, the members were charged with retrieving the bodies for proper burial and, if possible, hauling out the *Kookaburra*. Because it was determined that the aircraft couldn't be hauled without damage, the crew extended and improved the rudimentary runway Anderson and Hitchcock had cleared so that future expeditions could try to fly the aircraft out. (Ironically, the Thornycroft ran short on fuel and the group had to siphon some from the *Kookaburra*.)

Rumors that one of the Thornycroft members had found gold near the site inspired dozens of subsequent expeditions, but the desert scrub quickly swallowed up the *Kookaburra*, and it remained lost for 49 years.

Then Dick Smith, a Sydney helicopter pilot and subsequent *Kookaburra* researcher, took up the search. Two expeditions he led in 1977 proved unsuccessful, but the following year he got lucky. By then, bush fires had stripped *Kookaburra*'s airframe of its timber and fabric components, but its metal fuselage was still in surprisingly good shape. The airplane is now displayed at the Central Australian Aviation Museum in Alice Springs (see "Australia's Desert Aviary," Collections, Oct./Nov. 1998).

On April 10, 1979, the 50th anniversary of Anderson's landing, several local aviators visited the site where the aircraft had been found. They left a plaque, a mast to make the site more visible, and a water catchment device—a symbolic gesture to ensure water at the site. When the group revisited 10 years later, the tanks were brimming.


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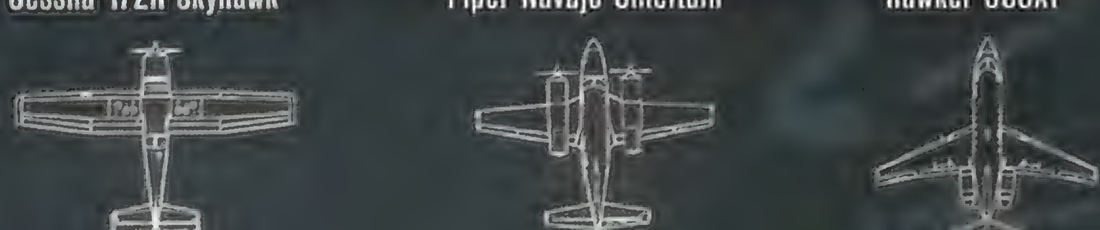

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The Legend of the Valkyrie

The XB-70 strategic bomber was too costly to survive but too magnificent to be forgotten.

by John Sotham

Most visitors to the U.S. Air Force Museum in Dayton, Ohio, know that one of its highlights is the sole surviving North American XB-70 Valkyrie, but a remarkable number complain that they can't find the airplane. According to museum volunteer Charlie Frey, they enter the hangar where the big bomber is housed, walk beneath it, and never realize that directly over their heads is the belly of the only Mach 3 bomber prototype the U.S. Air Force ever built. Frey, a grandfatherly type, listens to their pleas, then simply points behind them and up—*way* up.

Because of its size, the bomber is almost impossible to take in at close range. Instead, your eye wanders from one blistered and speed-scarred section to another: the long, slender fuselage and cockpit visor that make you feel like you're face to face with a giant snake, the gently curled leading edges of the huge delta wing, the square canards that accentuate the thin waist of the fuselage. No airplane ever built combines the sinuous carvings of supersonic aerodynamics with the awe-inspiring presence of a mighty weapon the way this one does.

And although it is just one of about 200 aircraft in the collection here, the Valkyrie casts the longest shadow, its unmistakable and otherworldly shape appearing on murals, etched into glass

The shape of things to come? The XB-70 Valkyrie program was canceled, but its legacy is a trove of still-useful data, and one surviving airframe.

USAF FLIGHT TEST CENTER HISTORY OFFICE

partitions, even emblazoned on the tray under your burger and fries in the museum snack bar. Pretty regal treatment for an aircraft that never saw operational service and of which only two examples were built.

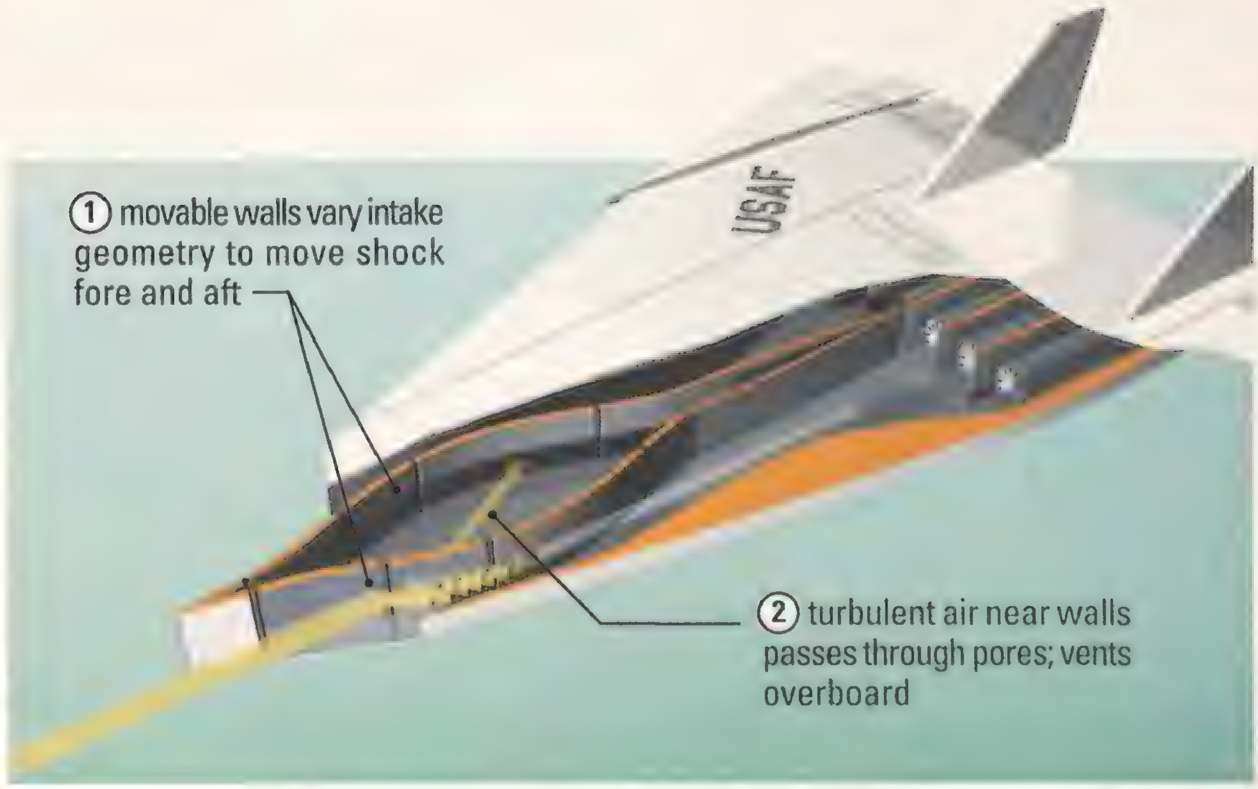
It's fitting that the creation of a strategic bomber so magisterial was set into motion by the man whose name is still synonymous with the Strategic Air Command: General Curtis LeMay became chief of staff of SAC in 1948 and immediately began refashioning it to cope with a growing Soviet threat. In 1954, the year following the Soviets' first detonation of a hydrogen bomb, SAC argued that the Air Force should develop a replacement for the Boeing B-52 Stratofortress, which was just entering squadron service. What SAC wanted was an airplane combining the huge payload and long range of the Boeing with the supersonic speed of the Convair B-58 Hustler, a troubled medium bomber program initiated in 1946. It was understood that such an airplane could not be built using current technologies, but technology was advancing so rapidly that it was assumed one simply wrote a requirement and technology would catch up.

It was also understood that president Dwight D. Eisenhower would not commit limitless resources to a military buildup. For the Air Force, the budget honeymoon was over, and the service coped, at least in part, by hedging its bets. Development of an engine, for example, might be funded by two or more airplane programs that would employ it—a sleight of hand that would end up hurting, not helping, the XB-70.

In 1954, the Air Force, based on a Boeing study, called for two parallel developments: an aircraft propelled in part by nuclear power and another "chemically" powered by a new kind of jet fuel with a boron additive that gave an added kick when injected into the afterburners. By 1955, Weapon System 110A was born on a piece of paper, and the Air Force called for 30 to enter service by 1963. The requirement evolved to a Mach .9 cruise followed by a Mach 2 penetration dash to the target, and the in-service date was extended to 1964. (The nuclear version would survive until 1959, and its cancellation would hurt the XB-70 program due to shared development on aircraft systems.)

In June, when contractors were invited in, Weapon System 110 A/L included a reconnaissance variant (the L part). With other aerospace firms up to their elbows in missile development and other programs, only Boeing and North American Aviation responded, and the contracts were mailed in November. Boeing submitted a design re-

NASM



JOHN MACNEILL

The key to sustained Mach 3 speed was inlet ducts using variable geometry to adjust the position of shock waves; porous walls vented turbulent air overboard. The ultimate goal was to ensure that the engines gulped subsonic air.

sembling its large swept-wing transports and bombers, while NAA's entry resembled an inflated SM-64A Navaho, a cruise missile then under development. But both versions attempted to cope with the range and speed requirements by affixing floating wingtips that supported giant fuel tanks to be jettisoned just before the high-Mach dash. Had these been built, no runway would have been wide enough to handle either craft. Both also incorporated canard surfaces for balance, but NAA, again based on its experience with the unmanned Navaho, placed the canard out in front of the pilot, apparently without realizing that it would block his view on landing. SAC, having none of it, sent both contractors back to re-think the problem. Meanwhile, the budgetary carpet was rolling up behind them.

In March 1956, Clarence A. Syvertson and Alfred J. Eggers, scientists with the National Advisory Committee for Aeronautics, had published a paper describing a phenomenon called compression lift. In simplified form, compression lift envisions a bullet-like shape being propelled at supersonic speed and surrounded by a high-pressure shock cone. If one placed wings on the bullet, the wing would divide the shock cone in two. Now saw off the top half of the bullet. The resulting half bullet under a wing created a compression wave that pushed up on the wing; the net result was indistinguishable from lift. Suddenly it seemed possible to discard the subsonic-cruise-with-dash-speed combination and build a Mach 3 vehicle with good enough lift and low enough drag to get the range needed.

NAA chief engineer Warren Swanson set about the task of coming up with the configuration. "One day we sat down and said, 'What is it that will give us the range they want?' " Swanson says. "We found that [the NACA] had tests on a one-half cone under a trapezoidal wing, and we saw that we could probably get the Mach number that way. We tried different shapes for the wings to fit the thesis."

By mid-1957 the pace of events picked up, and both contractors urged a quick decision, believing they had already fulfilled the contract. In September, the Air Force delivered the final refined specification, calling for a top speed of Mach 3 to 3.2 at up to 75,000 feet with a range of 6,100 to 10,500 miles at a maximum gross weight of 490,000 pounds. On December 23, NAA learned that it had won.

Funding trouble still hounded the program, though, as the Eisenhower administration pared and balanced budgets. In 1957, Air Force chief of staff general Thomas White announced a slowdown, and operational status slid even more, to 1965. In 1959, the boron fuel project was canceled; the XB-70 would have to fly on a formulation called JP-6. Then the F-108 Rapier, which would have shared engine development costs with the Valkyrie, was scrapped, putting added pressure on the XB-70 budget to bear the engine, escape system, and fuel system development burdens alone.

But Swanson and his team were making progress. Because the engine air inlets were a potential source of drag, their design was vitally important to the success of the aircraft. All turbojet engines—including the massive General Electric YJ93s that would power the Valkyrie—require incoming air to be at subsonic speed or they can't ingest it. After rejecting NASA studies that argued for placing the inlets across the back of the wing, Swanson and his designers placed two long tunnels in a single housing underneath the wing, with each duct supplying three engines.

"Some of our aerodynamicists thought that with a rectangular-shaped inlet we could get efficiency of nine-tenths at that Mach number," says Swanson. "The pressure loss going through the various shock waves [at Mach 3] was only 10 percent." In the inlets of the XB-70 (and the SR-71 Blackbird, which was being developed by Lockheed) the normal shock wave (at right angles to the direction of the airflow) that formed


Skywriter

EMPLOYEE REPORT

SPACE-AGE MILESTONES: XB-70 IN MAKING

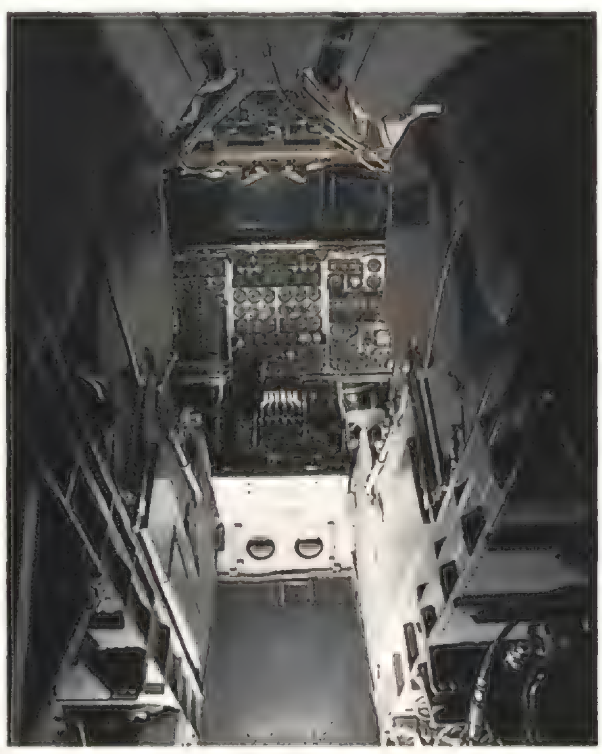
NORTH AMERICAN ROCKWELL

Structure, systems, aerodynamics, heat loads—design of the XB-70 sorely tested North American Aviation's engineers (left). Elevons and the folding wingtips' hinge lines are clearly visible from above on rollout day (opposite).

as the air slowed to subsonic velocity had to be held just inside the inlet, unlike what happened in slower supersonic aircraft like the B-58, which kept the shock wave outside. The design teams of the Blackbird and the Valkyrie each solved the problem differently: The Blackbird's engines use round spikes that move fore and aft to position the shock wave according to altitude and speed, while the XB-70 used a variable-geometry system made up of movable inlet ramps and venting ducts. "The purpose was to slow the air down from supersonic to subsonic using an external ramp on which oblique shock waves [at angles to the direction of the airflow] were formed," says Paul Reukauf, a project manager at NASA's Dryden Flight Research Center who, as a young engineering intern, was detailed to the XB-70 test program in 1967. "[The inlet] slowed those shock waves down and turned them a bit and compressed them to slow them close to Mach 1." A normal shock wave then formed just inside the inlet, and behind that, the air slowed to subsonic speed and entered the engines. "If the normal shock wave gets expelled, the whole shock train collapses and moves out in front of the inlet," Reukauf says. The result was a violent disturbance known as an "unstart." "You bring that normal shock wave in and control it...," says Fitz Fulton, a former test pilot at Edwards Air Force Base and Dryden who evaluated the XB-70 for the Air Force and NASA. "If it jumps out of the inlet, you get...a very strong buffet. One of the SR-71 pilots described it as a 'train wreck.'"

On the original XB-70, the pilots controlled the position of the final shock wave with a switch that moved the ramps inside the intake duct. Moving the shock forward produced the best pressure recovery and therefore the best range, but it was the least stable position for the shock in turbulence, which could disturb the flow and create an unstart. The shock was stable in an aft location, which protected it from turbulence but was less efficient.

Each YJ93 turbojet was capable of producing 30,000 pounds of thrust. The compressor section, like those of all axial-flow jet engines, was made up of alternating rows of rotating compressor blades and fixed stator blades. However, the YJ93 featured advanced variable stators (already used in basic form on the GE J-79) whose angle of attack could be varied to allow the engine to manage air at a wide variety of altitudes, pressures, and speeds. In much the same way, variable geometry—or swing-wing—aircraft like the F-14, B-1 and F-111 move their wings to tailor the airframe to streak at high speed in thinner air or slow speeds near the ground.



DAN PATTERSON

Much of the XB-70's design was derived from the development of the Navaho cruise missile. Its engine intakes, double vertical stabilizers (for high-speed directional stability), and forward canards (for greater pitch stability) were based on current aerodynamics but sometimes edged on the theoretical. And the sheer size and complexity of the Valkyrie made it an entirely new proposition. Swanson and his team had none of today's sophisticated computers, and wind tunnels hadn't yet been built to test designs under all flight conditions. NAA had a transonic wind tunnel that could accept only extremely

The Valkyrie's crew enjoyed a "shirt-sleeve" environment on a pressurized flight deck; loss of pressure triggered protective capsules that enclosed the seats (left). Paint applied too thickly—not heat—caused peeling; a shiny coating protected the tires (below). At high subsonic speed, the wingtips drooped to 25 degrees (opposite).

USAF FLIGHT TEST CENTER HISTORY OFFICE

small models, so the data gathered was of limited usefulness. The models' Reynolds number (a theoretical number in aerodynamics to account for the effects of scale) was too low, creating drag data that was artificially high.

But the airplane incorporated one truly unique innovation: Its hinged outer wing sections folded downward as speed increased, first to 25 degrees, then to 60 degrees. This feature provided at least three beneficial effects: By effectively reducing the aft wing area, it compensated geometrically for the way the center of lift shifted aft above Mach 1; less wing area, less lift. The folded tips also acted as ventral fins, aiding lateral directional stability and reducing the need for larger, heavy vertical fins. Finally, the wing tip vortices were forced beneath the airplane and trapped. The XB-70 was said to "surf" on its own shock wave, which led such aircraft to be called "wave riders."

"What the XB-70 did was to optimize that concept," says John Anderson, a National Air and Space Museum curator and an aerospace engineering professor at the University of Maryland who specializes in high-speed aerodynamics. "On other aircraft, the pressure has a tendency to leak around [the wings], but if you drop the wing tips and design the bottom surface to contain the pressure, you get high lift."

Interestingly, Swanson downplays compression lift, convinced that careful engineering, rather than wave riding, produced a successful design. "Compression lift, personally, was a sales tool.... We convinced ourselves that it was happening," Swanson says. "The whole shaping of the airplane was probably the most important part...the lift-over-drag [ratio] was phenomenal."

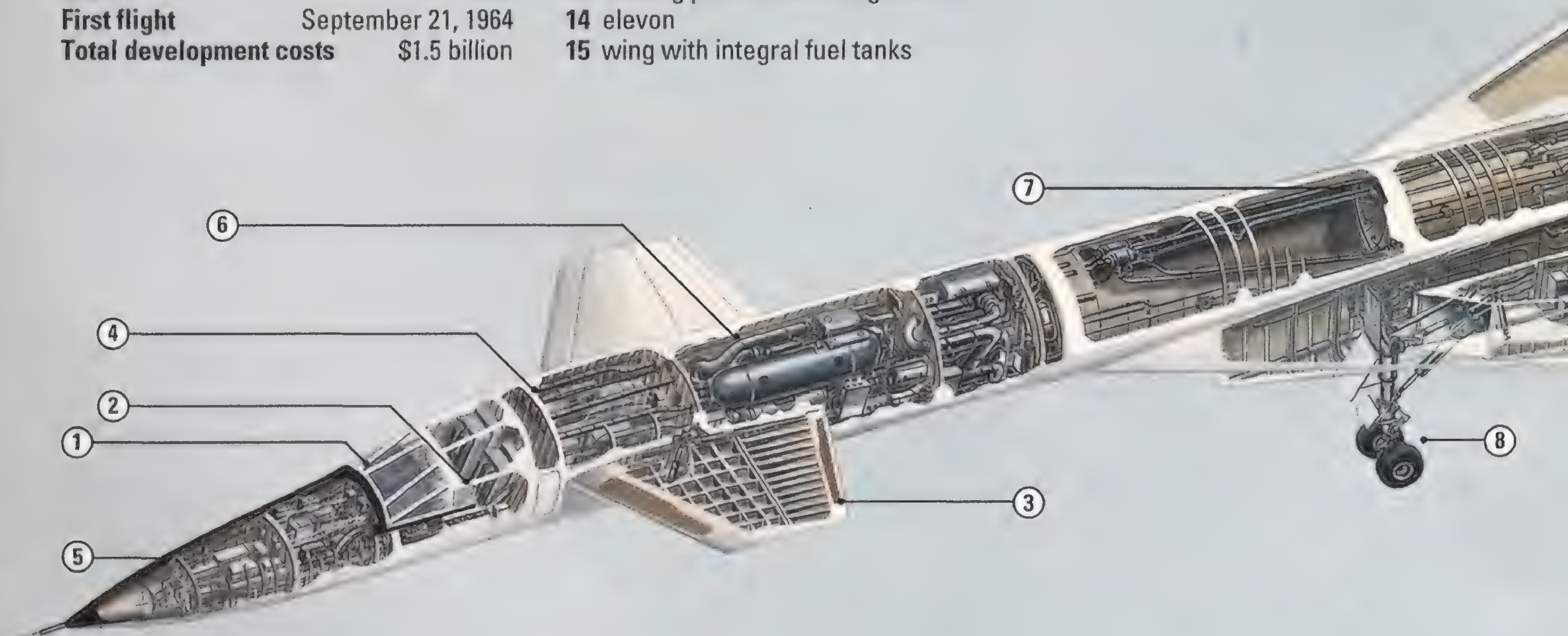
THE BOEING HISTORICAL ARCHIVES

Rather than being wowed by their creation, Swanson and his team were still trying to improve the design even as the first aircraft rolled out. "I don't think anybody felt that it was so advanced that it [couldn't be improved]," Swanson says. NAA designers took greater pride in the constant stream of patents that would contribute to future aircraft than in the XB-70 itself.

Some of those innovations focused on keeping the huge bomber cool. Mach 3 flight generates heat—a lot of it—as the friction of air scorches the fuselage and wing skin, raising temperatures to as high as 630 degrees Fahrenheit at the inlet lip. Conventional aluminum alloys clearly weren't up to the task and would soften. Titanium would be ideal, but it wasn't a practical choice for producing an entire fleet of strategic bombers. "There wasn't enough titanium in the United States at the time to build it," Swanson says. NAA used stainless steel honeycomb. Convair had used this new and expensive material in areas of the B-58 Hustler airframe that got exceptionally hot, and it proved to be the only workable solution for building nearly three quarters of the Valkyrie's airframe, including the wings, engine box, middle fuselage and vertical stabilizers. But it also proved to be difficult and costly to fabricate. "The airplane isn't square and isn't flat—you had curves to consider," says Ralph Ruud, who as an NAA vice president of manufacturing oversaw the construction of both Valkyries. "It was an entirely new manufacturing process from what we'd been used to. The honeycomb was brazed to the skin itself. You had a process of doing that under elevated temperature and you needed to

Length	185.8 feet
Wingspan	105 feet
Empty weight	231,215 pounds
Takeoff weight	521,056 pounds
Engine type	General Electric YJ93-3
Number of engines	six
Maximum thrust (per engine)	28,000 lbs.
Fuel capacity	43,646 gallons
Fuel tanks	11
Takeoff distance	7,400 feet
Rate of climb	7,170 feet per minute
Maximum speed	1,980 miles per hour
Maximum altitude	75,500 feet
Maximum range	3,417 miles
Endurance	1.87 hours
Crew	two
First flight	September 21, 1964
Total development costs	$1.5 billion

1 windshield ramp, movable
2 flight deck with escape capsules
3 all-moving canard with trailing edge flap
4 equipment bay
5 radome, polyester fiberglass (Vibran)
6 coolant system tanks, water, ammonia
7 fuselage with five fuel tanks
8 steerable nosewheel, retracts aft
9 main gear with fifth sensing wheel
10 hydraulically actuated hinged wingtip
11 movable vertical fin/rudder
12 YJ93-3 engine with afterburner
13 braking parachute storage area
14 elevon
15 wing with integral fuel tanks



State of the Art: Design Features of the XB-70

A snapshot of the 1950s, the construction of the XB-70 is representative of the materials and practices applied to high-speed aircraft at the time. Predicted hot spots on the Valkyrie's airframe might reach 1,000 degrees Fahrenheit—enough to soften aluminum. So the dominant material was a steel alloy formed into a honeycomb sandwiched between two steel sheets, panels of which formed the wing's skin. The wing inboard of the hinge lines held six fuel tanks, each tightly sealed to contain nitrogen gas, which prevented fire. Each wing had six combined elevators and ailerons—elevons—on the trailing edge that controlled both pitch and roll. When the wingtips folded, the two outer elevons were unneeded and locked flush with the trailing edge.

During takeoff and landing, the elevons became flaps for additional lift. To counteract the resulting nose-down pitching moment, the trailing-edge flaps of the canard surfaces hinged downward to increase the canard's lift and prevent the nose from dropping.

When airplanes transition through Mach 1, the center of pressure on the wing migrates toward the tail. The Concorde transferred fuel aft to re-balance, or trim, the airplane in the pitch axis. This avoided using the elevons to trim by altering the angle of attack of the entire wing, thereby creating drag. On the XB-70, the canard, which is a long distance from the center of gravity—essentially a very long lever arm—handled trim. By making only tiny adjustments in the angle of attack of the movable canard, the airplane can be trimmed through the transition and all the way up to Mach 3.

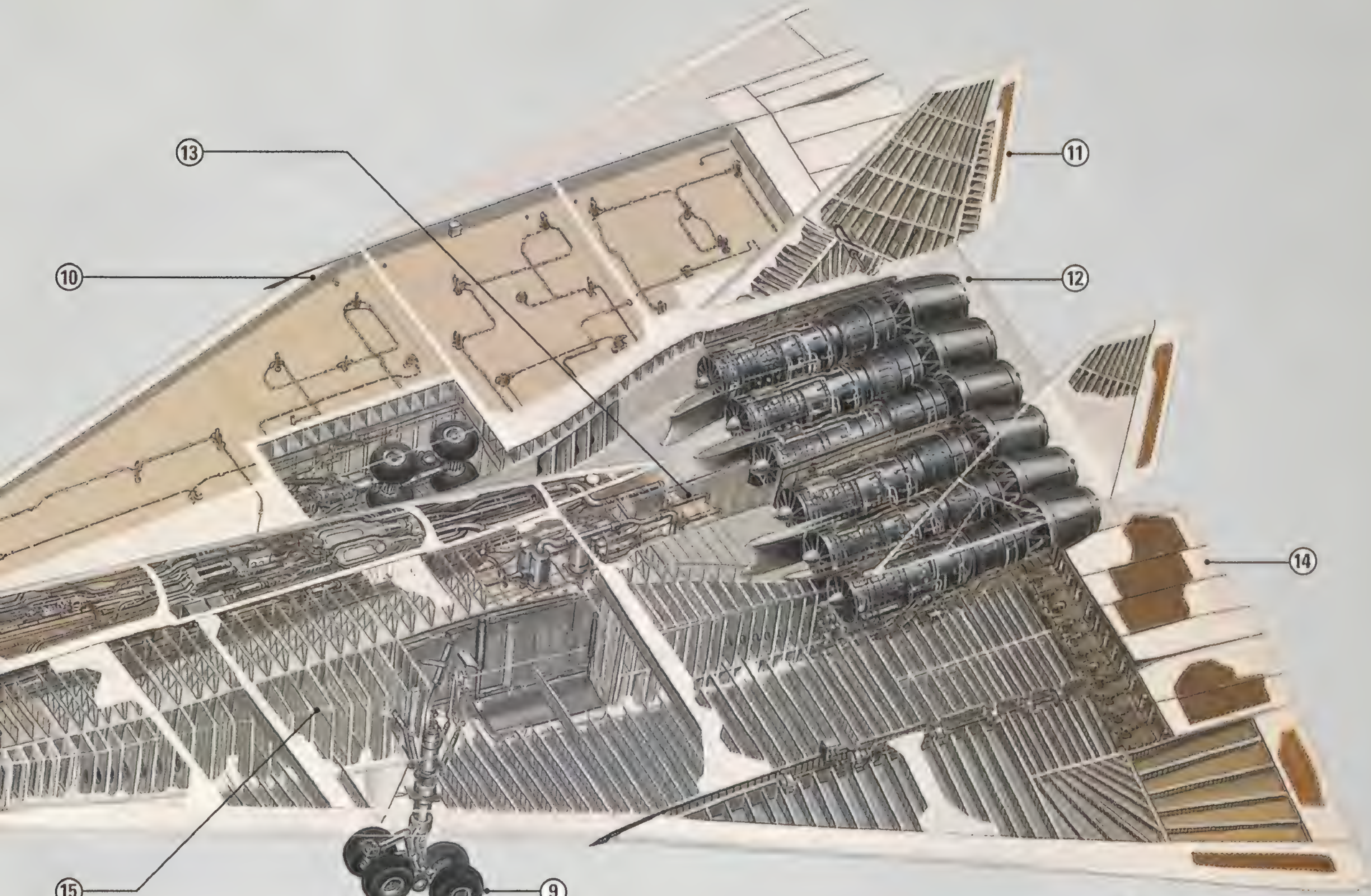
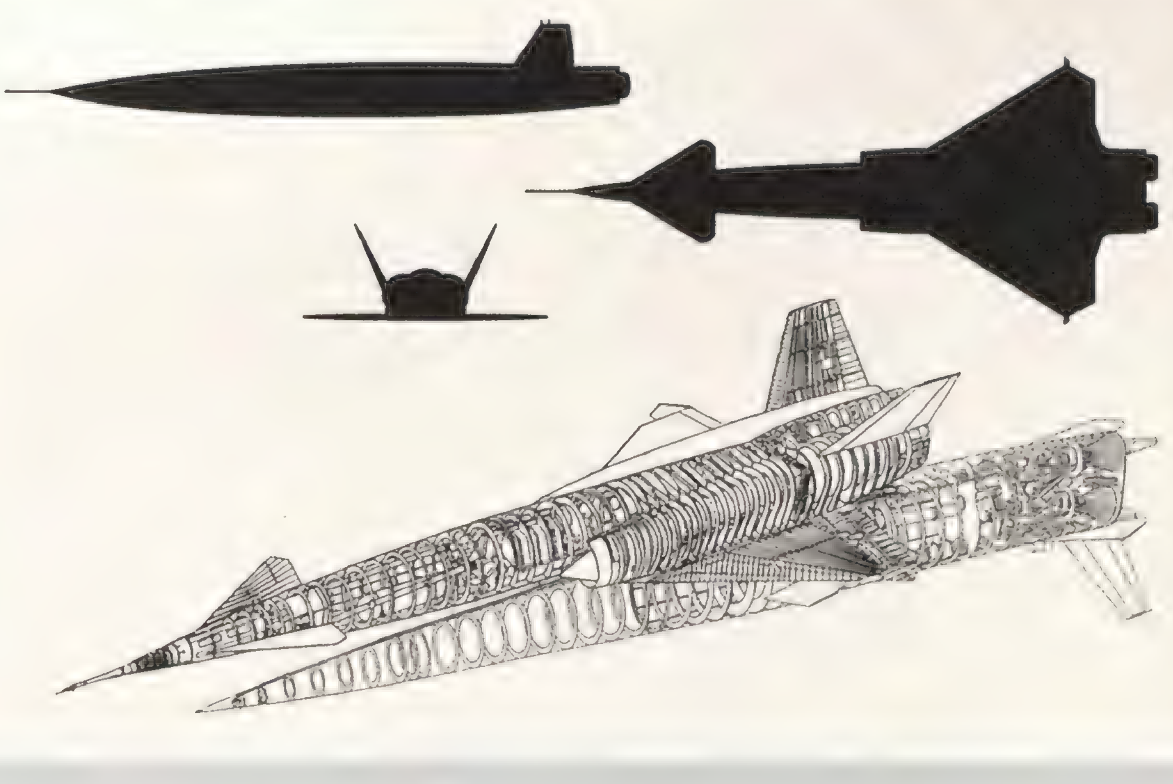


ILLUSTRATION BY JOHN BATCHELOR

The SM-64A Navaho, an unmanned cruise missile, had key features of the XB-70, albeit in a smaller package. The Navaho's wing had cropped tips to make room for the Mach cone shed by each wingtip. Both aircraft employ two vertical fins for directional stability with lighter, stiffer structure than one vertical fin. Two fins are seen in fighters such as the MiG-25 and Boeing F-15. The forward-mounted canard provides an effective surface to balance the airplane in pitch at high speed so the wing, relieved of the need to trim the airplane, can operate at the minimum-drag angle of attack.



USAF FLIGHT TEST CENTER HISTORY OFFICE

DAN PATTERSON

Flight testing at Edwards Air Force Base began in late 1964. Aircraft could be serviced on the "maintenance spur" off a taxiway (top). The second prototype arrived in mid-1965 but was lost during a freak midair collision a year later (opposite). The surviving airplane performed NASA research until its final flight in 1969 (above).

braze the sandwich. The skin was two [thin layers of steel] with honeycomb in between." After the skin layers were attached to the steel honeycomb, the integrity of the bond was tested with X-rays and ultrasound.

Because titanium was expensive, it was used only where it was required, primarily in the forward fuselage, and, as did the stainless steel skin, titanium demanded the development of new manufacturing procedures. "We had used titanium before, but in limited areas—most extensively in the aft [portion] of the F-100, and prior to that we had experimented with it in the F-86D," Ruud says. "I stamped out a piece the size of a silver dollar and [told the workers], 'That's what it cost.' " NAA engineers eventually turned to chemical milling, in which areas of material to be removed are left unprotected as the part is placed in a bath that etches the bare metal. The process was common in the manufacture of aluminum aircraft, and enabled parts to be produced with less waste of material. "You could do it with a curve or flat piece, or taper it: You could reduce thickness by progressively moving it out of the tank," Ruud says. Chemical milling procedures pioneered on the XB-70's construction were later used on the B-1B Lancer.

Besides the honeycomb skin, which acted to insulate the airplane's interior, the fuel acted as a heat sink. Also, water and ammonia in large tanks behind the cockpit provided fluids for a heat exchange system. The air-conditioned flight deck allowed a "shirt-sleeve" environment where its proposed four crew members could wear conventional flightsuits—a definite plus on long missions. For ejection or just a pressur-

ization failure, clamshell-like capsules closed around each crew member and quickly pressurized.

However, visions of a great white fleet of Valkyries to blanket the Soviet Union ended even before the XB-70's first flight, made on September 21, 1964. During the presidential campaign of 1960, candidate John Kennedy hammered the Eisenhower administration on its defense preparedness, but once he became president he too scrutinized the XB-70 program. In March 1961 Kennedy announced that the airplane would only perform research to explore high-speed flight. The production program was canceled a year after the downing of Francis Gary Powers and his high flying U-2. The ballistic missile, not the manned bomber, would become the keystone of U.S. deterrence.

Secretary of Defense Robert McNamara eventually allowed the construction of three, then just two, XB-70 airframes, to be used for research. The pair became perfect candidates for a NASA program that began in the mid-1960s to support development of a Mach 3 supersonic transport, or SST.

Testing was severely set back in 1967 when the second XB-70 struck an F-104 during a formation photo-op flight (see "Midair!," Dec. 1990/Jan. 1991). The second airframe had incorporated improvements suggested during flight tests of the first aircraft, and was much more heavily loaded with data-gathering equipment. After an investigation into the cause of the crash, the first Valkyrie continued to fly for the next year and a half.

Research centered on the potentially troublesome effects of sonic boom. Fitz Fulton and Joe Cotton began flying the Valkyrie over an instrument-equipped test range that spanned several states. The loud report of an aircraft breaking the sound barrier can be more than just an annoyance—some large supersonic aircraft damage buildings when their pressure waves hit the ground. XB-70 research revealed that the force of the boom varied not only with an aircraft's speed, but also its gross weight. Also, during some test runs, after the XB-70 had turned, its shock waves sometimes combined and doubled the effects on the ground. It became clear that a supersonic transport would have to be carefully tailored to reduce sonic boom. Many of the XB-70's noisome test flights extended over Idaho, and it is said that Cotton carried two five-pound bags of potatoes on one of his flights to be given to representatives of towns on the flight path with a high percentage of broken windows.

As more instruments and equipment were installed, the SST study shifted to stability, inlet performance, and potential structural problems like fuselage flexing and loads on the canards. "We were primarily looking at the problems of operating an airplane at high altitude and high speed," says Fulton. "[The XB-70] was and is the biggest airplane to operate at Mach 3." To gather information on structural dynamics, the Valkyrie was equipped with the ILAF—identically located acceleration and force—package, which consisted of exciter vanes on the fuselage that induced structural vibrations of known amplitude and frequency. The aircraft's stability augmentation system, which reacted to signals from accelerometers, then automatically manipulated the control surfaces to help maintain smooth flight. Some XB-70 crews had complained about uncomfortable buffeting and trim changes caused by clear-air turbulence and changes in outside air temperature. Such upsets merely annoyed test pilots, but could prove intolerable to high-rolling vacationers jetting from New York to Paris in an SST.

"The XB-70 was a high-workload airplane…up above Mach 2, about half of the copilot's time was spent monitoring the inlets," Fulton says. "I don't think the airplane was particularly difficult to fly, but it took a lot of attention." Having to rely on the first Valkyrie, which didn't feature the automatically controlled inlets found on the second aircraft, made it clear that the comfort of SST pilots—not just passengers and Idahoans—would be an important design factor if such an aircraft were to enter regular service.

Later flights helped determine if the XB-70 was capable of sustained flight at Mach 3. "That was a requirement, so that the heat would seep down into the innards—the bone marrow—of the airplane," says Cotton. On October 14, 1965, Cotton and Al White reached Mach 3, but in the process, the Valkyrie lost nearly 10 feet of skin off the leading edge of its wings. "[The aircraft] rolled around a bit and there was noise and a definite disturbance," says Cotton. "We had scars all over the airplane. If you look at the one in the Air Force Museum, you might say it's band-aided. There are patches all over that machine, but I'm proud of every scar there."

NASM

AIR FORCE MUSEUM/WRIGHT-PATTERSON AFB

The XB-70 was capable of maintaining its advertised top speed, but not without getting roughed up—another potential problem for future TWA and Pan Am mechanics. Besides requiring constant repairs to its skin, the aircraft leaked fuel and was plagued by landing gear and brake malfunctions, as well as leaky hydraulics. "We had problems with the mundane stuff," Cotton says. The exotic systems—the wing folds, inlets, analog and digital data systems in the bomb bay—worked fine. Cotton and White solved one in-flight nose gear malfunction with a decidedly low-tech solution—a paper clip—which Cotton used to jump two circuits and lower the gear, after careful consultation with engineers on the ground.

While giving a tour of the XB-70 to Charles Lindbergh, Cotton explained that in addition to gear problems, malfunctions that locked the wing folds in positions that prevented a safe landing would require Valkyrie crew members to eject. Lindbergh, hoping to fly on a future SST, asked, "All 200 of us?"

After NASA's SST research program turned to the SR-71 and the third, partially built XB-70 airframe was scrapped, the surviving Valkyrie took its final flight, to the Air Force Museum at Wright-Patterson Air Force Base in Dayton, Ohio, on February 4, 1969. On that day, aviation photographer Dan Patterson was a 15-year-old high school sophomore skipping school—with his father's blessing. "It was absolutely the most amazing thing I've ever seen in the air.... I've seen the Concorde land and fly, and that's pretty sharp, but the XB-70 was like it was from another world," he says.

As its engines spooled down and fell silent, the XB-70 began its final mission as a museum exhibit, a fate all the more galling to those who believe the Valkyrie's tremendous power was barely realized, especially since follow-on airframes promised even more capability. "Think about the third Valkyrie—she was going to be the ultimate weapon," says Jeannette Remak, a researcher who recently co-authored a book on the Valkyrie with former Air Force Museum curator Joe Ventolo. "They had a plan to [make it] a satellite killer. We could have been way ahead 30 years ago."

But to most air power historians, the XB-70 was a dead end, despite being a fantastic aeronautical achievement. "We haven't tried to surpass the XB-70 because we haven't needed to," says Raymond Puffer, a historian at the Air Force Flight Test Center at Edwards. "The emphasis is on low-level and stealth. High speed is not a paradigm these days, even among fighters. Some reach Mach 2, but combat is subsonic." Puffer says that the more compact B-1, which features variable-geometry swing wings, was able to absorb the design changes necessary to take it from the stratosphere to streaking a few hundred feet above hilltops and canyons. And even after countless modifications that have strengthened its aged airframe and replaced vacuum tubes with modern electronics, the Stratofortress still flies—but only when air defenses are timid, or when it can launch standoff weapons far from any potential threats.

Like the B-52, the Valkyrie was formed of massive surfaces and sharp angles that would have created a serious handicap. "One of the basic reasons it was canceled was that with the big inlets and tips folded down, it made a marvelous radar target," Swanson says. "It would have been very detectable at high altitudes. We began to think about that from the day we started the project."

Swanson consulted with a British radar cross section expert, who predicted the Valkyrie would indeed be quite vulnerable to detection. Also of concern was the heat signature generated by the six engines, but it was thought that no aircraft could reasonably be expected to track the Valkyrie from behind because of its tremendous speed. "It all came to a big head when Robert McNamara came out to the plant and saw the airplane," Swanson says. "He

USAF FLIGHT TEST CENTER HISTORY OFFICE

As big as hallways, the intake ducts measured six feet high and 80 feet long (left). A smaller, fifth wheel amid the main gear bogies was wired to the braking system (top). A B-58 Hustler, the Air Force's only supersonic bomber, flew chase on many longer tests because nothing else could (opposite).

USAF FLIGHT TEST CENTER HISTORY OFFICE

thought that it would be a better strategic method to have a small aircraft overfly the enemy and [help direct] a ballistic missile to land on the spot. I suspected at the time he was talking about the YF-12 [predecessor of the SR-71 Blackbird]."

Ballistic missiles may have offered some advantages over manned aircraft for attacking the Soviet Union, but assuming that bombers would be kept in the arsenal, Swanson believes that estimates of the Valkyrie's survivability were skewed by the loss of Francis Gary Powers' aircraft. The 1960 shootdown proved that U-2s were vulnerable, Swanson says, but "didn't prove that an airplane flying at Mach 3 at 75,000 to 80,000 feet could be brought down...." The SR-71's apparent invulnerability supports his argument.

However, even if the Valkyrie's demise as a warplane was inevitable, its true contribution—aborted SST plans in the past notwithstanding—has yet to be realized in future aircraft that will cross oceans in minutes, not hours. Engineers recently reviewed XB-70 test data while working on the design of NASA's high-speed civil transport, another proposed Mach 3 airliner. The HSCT was canceled, but an even more advanced vehicle is in development, one that still draws on the Valkyrie. Engineer Paul Reukauf who works on development of Hyper-X, an experimental unmanned aircraft that will operate at Mach 8 to 10, says, "There is exactly a direct correlation between XB-70 and SR-71 work and future projects like the Hyper-X." The XB-70 and the SR-71 were propelled not only by their turbojet core engines but also by the powerful compression of air as it moved through their inlets before entering the engines. "In fact, the scramjets and ramjets we're looking at are basically the same engine as the intakes of the SR-71 and the XB-70 if you injected fuel behind them," Reukauf says. "The propulsion technology [for a hypersonic transport] is pretty well in hand because of those aircraft."

But more than 30 years after it last flew, the Valkyrie continues to arouse emotion. Its legacy is still growing, and Dayton museum volunteer Charlie Frey keeps a notebook that gets fatter with time. The museum's expert on all things Valkyrie, Frey knows most of its secrets: He shines his small flashlight into the nose gear well of the aircraft to illuminate a bird's nest he found tucked behind hydraulic tubing, built while the aircraft was stored outside for nearly 20 years.

As he stands next to the XB-70's left main gear, its silver-tinted, heat-reflecting tires as high as his chest, Frey explains the complicated contortions the strut endured as it retracted. The Valkyrie's wheel wells are aft and inboard of the strut, out of line with the wheels, which often puzzles even spatially savvy visitors. Frey reaches into a pocket of his red volunteer's vest, festooned with aircraft pins and patches, and produces a four-inch model of the strut that he made from balsa wood and model aircraft wheels. He animates the hinged model with his fingers to illustrate the retraction sequence.

When visitors ask about the midair collision that claimed the second XB-70, Frey pauses, steps back, and delivers a well-researched account of the events that day, using his hands to illustrate the flight paths of both the doomed aircraft. He's a regular one-man Valkyrie show. At closing time, when the visitors file out, they've seen what they came to see, and Frey has kept the legend alive.

Comm

Infrequent Fliers | T.A. Heppenheimer

There are not now, and will not be anytime soon, airliner-like launch vehicles that fly into orbit routinely and on frequent schedules. Promising that there will be merely transforms hard-won successes into apparent failures.

When it launched the space shuttle program, NASA hoped the new vehicle would reduce the cost to lift payloads into orbit to as low as $160 per pound. Francis Clauser, dean of engineering at California Institute of Technology, suggested that NASA might fly up to 40,000 missions before flight costs would begin to eat up a major share of the agency's minimal budget. Lockheed's Max Hunter, a leader in space shuttle design, proposed $7 per pound. Barron Hilton spoke of hotels in orbit. Shuttle operations would be as routine as...well, as routine as an airline's.

Such expectations were simply unrealistic. Worse, we don't seem to have learned from that experience; we may be about to arouse unreasonable expectations again.

It is time to state clearly what is obvious: There are not now, and will not be anytime soon, airliner-like launch vehicles that fly to orbit routinely and frequently. Current airliners fly several times each day because they need little maintenance and can be turned around at the gate with minimal fuss. They are rugged, sustain comparatively modest stress, and deliver years of service. Granted, it took decades to get from Great Britain's Comet jetliner, which proved the feasibility of regular jet service in 1952, to today's turbofans, which are so reliable that we trust a pair of them to take us across an ocean.

But despite almost 20 years of operation, the shuttle is nowhere near an airline-style routine. Its systems are far more complex than those in commercial service. Its main engines use liquid hydrogen fuel, which demands extra care. Other systems use toxic and corrosive chemicals. Complex equipment is packed into tight compartments, making it hard to reach for service.

The shuttle also must withstand extreme stress. Its main engines experience high internal pressures, and its turbopumps produce extreme power from an ultra-compact package. A complete set of shuttle turbopumps would fit on your dining room table, yet their power would drive an aircraft carrier at flank speed. To protect the shuttle on reentry into the atmosphere, it has 31,000 insulating tiles, each of which requires meticulous attention.

> The most anyone hopes for is that the next new launcher can achieve somewhat less in 2005 than NASA promised for the shuttle in 1972.

Before a flight, NASA does not simply load a spacecraft into the payload bay as if it were air freight. Each unique payload must be integrated with the vehicle. This means removing wire harnesses from the previous mission and installing new ones, along with new instruments. Standardized payload installations would save time during preparation for flight, but they also add weight.

Following a return from orbit, the shuttle spends up to three months at the Kennedy Space Center in Florida, where it receives extensive tests, maintenance, and checkout. Only then is it ready to undergo preparation for another flight.

The next-generation vehicles will cut the time between flights substantially. At the Skunk Works of Lockheed Martin, the X-33 is approaching flight test. By the summer of 2000 it is to test important new technologies in suborbital flight. Company officials hope that the X-33 will lead to a new vehicle called the VentureStar, which may enter service as early as 2004 and lower the cost to orbit from the shuttle's $10,000 per pound to only $1,000.

VentureStar will be unmanned, which eliminates crew accommodations and life support. It will have none of the shuttle's toxic propellants, which need a facility of their own at the Cape. Custom payload integration is out, as VentureStar will have standardized payloads in interchangeable canisters.

VentureStar will be built of graphite-epoxy, which is light and should allow it to fly directly to orbit. Its low weight will also allow it to glide high in the upper atmosphere on reentry, losing speed slowly in a prolonged descent that will substantially reduce heat. Its thermal protection can be simpler and lighter, using panels of Inconel, a nickel steel. Such panels have been tested in wind tunnels and in flight aboard *Endeavour*, carefully placed to receive only the reduced heat of VentureStar and not the shuttle's higher thermal loads.

While Inconel dates back to the 1950s,

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Lockheed will also employ new technology. The main engine is called an aerospike. Simpler than the shuttle's engines and operating at lower pressure, aerospikes will provide both the boost to orbit and the necessary maneuvering power while in orbit, eliminating the extra engines the shuttle uses in space.

To power its ailerons and landing gear, VentureStar is to use actuators powered by nickel-cadmium batteries. This system will be far easier to check out than the shuttle's, which uses a turbine powered by noxious hydrazine propellant, a process that produces poisonous ammonia. For overall checkout, the onboard systems of VentureStar will have advanced monitoring sensors to pinpoint problems.

The bottom line? Whereas the shuttle takes months to turn around for reflight, VentureStar is to take mere days. The X-33 is to fly two consecutive flights with a seven-day turnaround, as well as one more with a two-day turnaround. Such rapid reflights are not new; X-15s achieved them during Mach 6 flights as early as 1962. The VentureStar systems are to be derived from the X-33, improving its prospects for less time in checkout.

It all sounds too good to be true, and it is. No one has ever built a rocket that flies to orbit as a single stage, let alone used it to achieve low cost.

The X-33 is already more than 30 percent over its initial empty weight of 63,000 pounds. This was to be 23 percent of its loaded weight, allowing enough fuel for the X-33 to reach Mach 15 or higher. It was to launch from California and land 950 miles away, in Montana. However, it already weighs 83,000 pounds, and its top speed is only Mach 10. Such a modest reentry speed will not give an adequate test of its thermal protection. A similar weight increase would doom VentureStar, by cutting its payload sharply or preventing it from reaching orbit altogether.

DAVID POVILAITIS

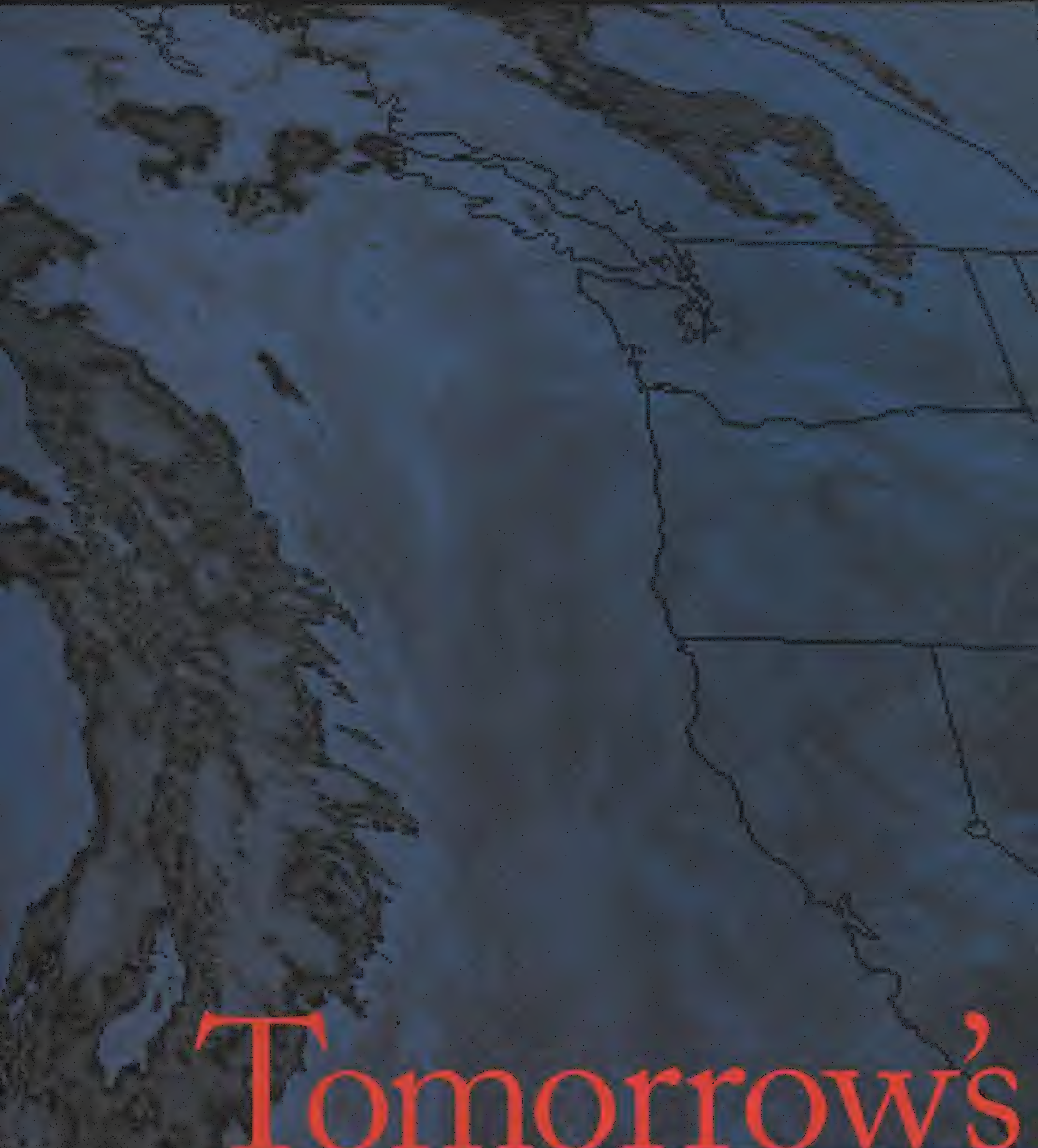
For VentureStar, the ratio of empty to loaded weight will be only 9.8 percent: 6.5 percent for structure, 2.6 for engines, and 0.7 for onboard systems. Such numbers are not science fiction. The structural weight fraction of the shuttle's external tank is even lower: 4.0 percent. Still, the tight margins of VentureStar will push the limits.

Lockheed Martin plans to build VentureStar as a private-sector program, which suits NASA's Dan Goldin, who has given a series of fiery speeches calling for new designs. Yet Goldin, with a space station to pay for, has capped NASA's contribution to the X-33 at a flat $941 million. Above that level, the overruns are Lockheed Martin's to eat.

The most anyone hopes for is that VentureStar, which lies at the far limits of the possible, can achieve somewhat less in 2005 than NASA promised for the shuttle in 1972. Even so, VentureStar and its prelude X-33 are important. If they are not hampered by unreasonable expectations, they could show that the means are in hand to usher in an era of spaceflight that will feature lower costs and more routine operation.

That will still be a long way from the pace of airline operations. Visit a major airport such as Los Angeles International. Within a few hours you may see a hundred takeoffs and landings. Now consider that it has taken 20 years for the shuttle to make a hundred flights. The difference shows how far we are today from airline-like spaceflight—and how far we are likely to remain.

Frequent contributor T. A. Heppenheimer holds a Ph.D. in aerospace engineering from the University of Michigan and has held research fellowships at the California Institute of Technology and in Germany. He is the author of *Turbulent Skies*, a history of commercial aviation. He is currently writing a history of the space shuttle for NASA.



Tomorrow's

FAR OUT IN THE PACIFIC, SCIENTISTS TRACK

THE RIPPLES FROM EL NIÑO AS THEY

NOAA's WP-3D Orions, famous for hurricane research, explore weather systems all over the world.

The Orion's probes and sensors measure wind, humidity, even electric fields.

Storm

by Carl A. Posey *Photographs by Scott Highton*

GATHER STRENGTH AND HEAD FOR THE COAST.

Sean White of NOAA's officer corps served as navigator on many 1998 Pacific storm missions.

Among the lithe bizjets on the ramp at the Monterey Peninsula Airport in California, the aging turboprop looks out of place, a visitor from another epoch. Oldtimers sometimes mistake it for an Electra, Lockheed's 1950s airliner, because instead of the forlorn gray of its Navy cousins, it wears a polished white coat trimmed in blue, with crimson flaps and red, white, and blue bars on the broad tips of the propeller blades. A candy-striped probe extends from the right front fuselage, and there are radomes everywhere—one in the nose, a retractable one tucked under the chin, another, shaped like a stubby pencil, in the tail. An Electra with mumps, maybe. In fact, the airplane is a renowned laboratory, one of a pair of Lockheed WP-3D Orions custom-built in the 1970s for the National Oceanic and Atmospheric Administration.

Expensive to own and operate—NOAA paid almost $40 million to build and equip the pair—the Orions were bought for Project Stormfury, an experiment that once held the promise of reducing the destructive winds of hurricanes. Though Stormfury died in the 1980s, the aircraft have earned their keep by utterly changing the way hurricanes are studied, a fact celebrated by the 63 hurricane glyphs—one for each storm flown—painted on Orion N42RF's belly. Farther down the fuselage 32 foreign flags are painted in a grid, showing that the Orion has carried its instruments and probes into almost every weather, almost everywhere.

The NOAA Orions are the most capable in a series of craft that have flown since the early days of weather science, when instruments were strapped to kites, then balloons, then open-cockpit biplanes. Scientists send such probes to observe parts of the atmosphere as they behave in the real world and to get information they use to construct virtual worlds—numerical models that enable them to reduce the atmosphere to something they can see more or less whole, albeit only on the most powerful computers. A daily torrent of data from balloon-borne sondes, ocean buoys, radars, satellites, weather stations, and a host of other sources around the planet fills in the models' layered grids, and the models, powerful mathematical equations, create the atmosphere as it should be a few hours, a day, or a week into the future.

Despite the global reach of modern meteorology, however, there are vast holes where a lack of understanding or data—or both—hide that atmospheric future. For example, the Pacific Ocean is almost free of data collectors, save a relatively few buoys, some ships, and satellites. To see what is really happening in the persistent low-pressure

THE SEARCH FOR THESE LOW-LEVEL JETS IS WHAT BROUGHT 42RF TO MONTEREY IN EARLY 1998 FOR A PROJECT DUBBED CALJET, AND THE HUNTING HAS THUS FAR BEEN GOOD.

system south of the Aleutians, where much of North America's worst winter weather incubates—or an Indian Ocean monsoon, or El Niño events, or Alpine winds, or hurricanes and typhoons—you need an airplane stuffed with instruments, like N42RF, now about to fly into one of the storms that wrecked California in the early months of 1998.

The Orions have been probing everything the atmosphere contains since the 1970s, and it is clear they've done some heavy hauling. This is not to say they've lost their looks, for the grooming they receive at their MacDill Air Force Base headquarters near Tampa, Florida, would summon envy in a Hollywood star. And they enjoy a sort of immortality. Since Lockheed has ceased building Orions, some retired Navy planes have become organ donors for the NOAA aircraft.

Inside, 42RF is spartan—basic green metal covered with gray canvas-like fabric, and seats are as utilitarian as those in a Soviet typing pool. Cuisine, for passengers who bring no rations with them, is white bread and peanut butter, and soft drinks to wash it down. Knobs, tables, switches, the subway-style overhead rail you clutch while making your way down the aisle in heavy weather have all been chipped and burnished by use. People have spent years aboard this airplane, for its legs are exhaustingly long.

Today's March flight—the 21st sortie this winter—is a case in point. It is scheduled to last just over nine hours and cover more than 2,000 miles, ranging from about 20,000 feet down to a few hundred feet above the waves, where the atmosphere shades into the sea—and where the scientists on board hope the airplane will encounter a vast river of moisture-laden air hurrying northward between the incoming storm front and the California coast.

The search for these rivers of air—what meteorologists call prefrontal low-level jets—is what brought 42RF to Monterey in the first three months of 1998 for a project dubbed CALJET—California Land-Falling Jets Experiment—and the hunting has thus far been good. In February, the P-3 flew into a 180-mile-wide, 100-mph jet 250 feet off the sea. When it and the storm following it made landfall, all hell broke loose along the California coast—as did a section of the coast itself. In the days following the storm, nine died in floods and mudslides, a number that eventually grew to 17 by the end of the storm season, when 40 of the state's 58 counties had been declared federal disaster areas, with statewide damage estimated at $550 million.

That winter, there seemed to be a link between the low-level jets and a vast pool of warm surface water farther south—the oceanic footprint of El Niño. It may be this connection that increased the number of fronts sweeping into the mid-section of the West Coast and, therefore, the number of jets available for study. Had the study been planned for this past winter, when El Niño did not appear, there would have been far fewer samples in the survey.

Moreover, the very term "El Niño" has a certain cachet—in an era when everything from the deluge to the Dow is being attributed to this periodic warming of the eastern Pacific, El Niño is a star to which only the most unworldly

of scientists would not wish to hitch their wagons.

In charge of the CALJET wagon for today's flight is Ola Persson, a Swedish-born meteorologist with the Boulder-based Cooperative Institute for Research in Environmental Sciences, run jointly by NOAA and the University of Colorado. A tall man with wild, curly, brown hair, he rushes between his chief-scientist seat behind the pilot to the various stations up and down the fuselage, like a skinny bee tending a honeysuckle hedge.

"We're trying to find the role of the jet in producing precipitation in the mountains," Persson explains when he has time to talk. "It comes from fairly far south, from a warm, moist region. Its moisture, heat, and high winds make it a feeding tube into the storm system." The scientists are also studying the exchange between the jet and the ocean—whether the air gains or loses heat and moisture as it travels.

"The project was designed before El Niño hardened. But last summer the experiment and nature came together," Persson says—perhaps only coincidentally. "We're uncertain what causes what—a chicken and egg thing," he adds. "We don't know how the El Niño affects these storms. We hope to pull some link out of the data."

Persson and Marty Ralph, his co-investigator on the CALJET project, make their decision on the timing of today's flight from data assembled by John Daugherty, a Colorado-based researcher from the National Center for Atmospheric Research and NOAA's National Severe Storms Laboratory. Daugherty's satellite images show a shattered comma of weather the size of California, Oregon, and Washington bowed toward Monterey, its 2,000-mile-long tail of cloud dropping south and west—reaching, perhaps, into the El Niño reservoir of warm water.

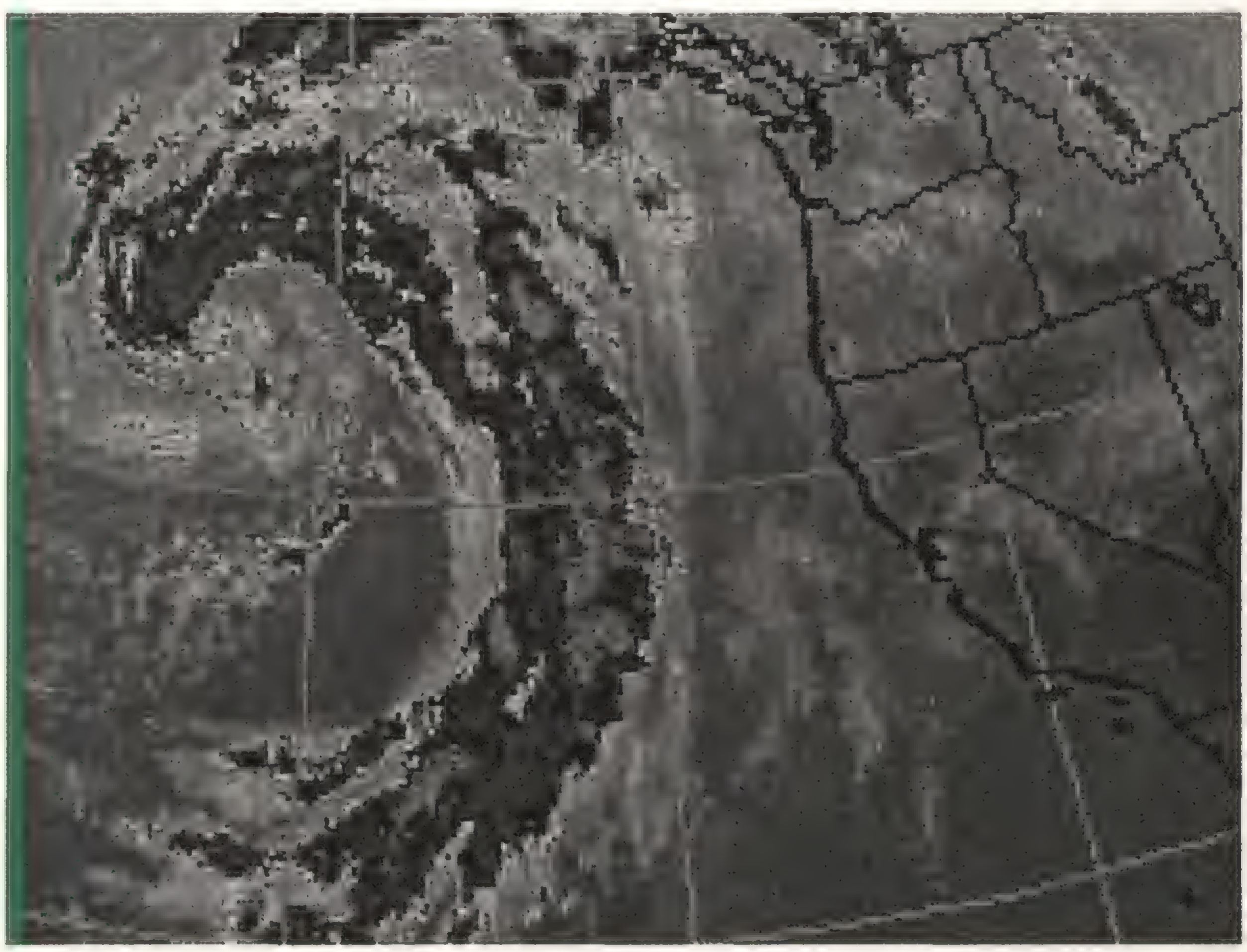
Only the pilots have a better view than the one out the big portside bubble window at the cloud physics station, just forward of the stubby wing and its two nacelles. On the station console, images from a video camera in the nose provide a look ahead at a swath of cloud that is the vanguard of today's storm, the striped gust probe like a lowered lance aimed at its cloudy heart. Click, and the screen shows Monterey gradually receding into the salt haze and blue sea. Click, and there's a view straight up or down.

The Orion's myriad other sensors report speed, position, track, heading, altitude, humidity, water droplet sizes, atmospheric water content and whether it's vapor, liquid, or solid—it's like flying inside a living thing covered with a sensitive skin. Another screen shows the sweep of the nose radar and the Doppler radar in the tail; the belly radome extends into the slipstream, and that radar starts sweeping the sky for a hundred or so miles around the airplane. The screens are like a gallery of abstract paintings, with no two images quite alike.

"Okay, folks, we're going to start our maneuvers now," says Stan Czyzyk, today's flight director—the liaison between the air crew and the scientists—seated just forward of the cloud physics spot. These aren't split-S's or snap rolls, but small calibrating movements. First the Orion oscillates in pitch, flying nose up, nose down, moving like a whale through the air; then it sideslips in a waddling yaw at various indicated airspeeds. Then 42RF resumes its steady march westward, still so gravid with fuel that 18,000 feet is all it can do.

Just aft of the cloud physics station, Dave Jorgensen and Tom Shepherd sit side by side at the radar management post, monitoring the data from the Orion's sensors, keeping things going. Jorgensen works for the Severe Storms Laboratory, but he was in the hurricane trade for many years. His first hurricane flight was into Caroline, in 1975, aboard the uncomfortable DC-6. Shepherd, also from the severe storms lab, is the data manager aboard. Now and then a radar or computer crashes and there is a flurry of hands, rebooting.

Shepherd enters the events of the flight in a computer log that automatically records the aircraft's latitude, longitude, track, and altitude with each entry, along with universal time. At 1939 Zulu, he recorded, "Engine start." A few minutes later the entry was "Thin upper cirrus covering 80% of the sky. Very nice day here in Monterey, too bad we have to work."



NOAA

In a GOES-9 satellite image, the target for a March 1998 CALJET experiment is a vast arc of moisture, spun by winds around a low-pressure center. What is not visible to the satellite—to the regret of weather forecasters—is the prefrontal jet that causes heavy rain when the storm system makes landfall.

NOAA

Flight-level winds encountered by 42RF on its March 11, 1998 CALJET mission were recorded along its trapezoidal flight track. Arrows along the flight track indicate the wind's strength and direction, and the colored bar along the side of the map represents altitude. The chart shows that at 18,000 feet, the altitude at which most of the mission was flown, 42RF encountered strong southerly winds (that is, blowing from the south) as it flew through the storm system on both its outbound and its inbound legs. These winds are indicated by the series of longer arrows on the track.

In the lower right corner of the trapezoid, the flight track changes from red to lavender and pink in the area where 42RF dipped down to about 500 feet to sample the winds of the low-level jet, which, weaker than the winds at higher altitudes, were measured at about 50 mph. Scientists are using the data to refine computer models.

The two scientists' heavy-weather backgrounds are good credentials for this exploration of what are being called El Niño storms. They are not as wing-bendingly terrible as hurricanes, and, while ten times larger, they are easier to fly. Where hurricanes reach from the ocean surface to 50,000 feet or more and run on a powerful chimney of convection, these Pacific storms typically have cloud tops below 30,000 feet and are not so violent. But they touch millions of lives. Today's storm will hit the waterlogged California coast tomorrow morning, sweep across the continent, and drift into the Atlantic a week later. In winter, these storms decree the weather for an entire continent.

An hour and a half from land, the airplane slides between cloud layers, a vast purple surround on the belly radar display; cumuli poke up from the lower cloud deck like cauliflower. One imagines Amelia Earhart at the end, lost between such clouds. There is less and less chat on the air traffic control frequency, as if the Orion leaves not only the land behind, but the world as well.

At NOAA's National Center for Environmental Prediction near Washington, D.C., Budapest-born scientist Zoltan Toth and his comrades in prophecy are attempting to break ground in long-range weather forecasting. Instead of simply calling for more and more data indiscriminately, Toth and his colleagues are identifying what they call sensitive areas—targets where more data in the models will make a difference in their accuracy—using a technique called ensemble forecasting. Toth has conferred with Persson to determine a targeted area for today's CALJET flight. Data collected from that area will, Toth believes, improve weather forecasts about four days hence.

The bull's-eye is a rough cluster of concentric lines floating over the North Pacific and centered at about 140 degrees west longitude. Sean White, a lieutenant commander in NOAA's officer corps and today's navigator, pushed 42RF's flight track as far west as possible to hit the bull's-eye and still get the airplane back to Monterey.

To reckon sensitivity, Toth uses models from the European meteorological facility in Reading, England, along with Canadian, other European, U.S. Navy, and NOAA models—17 in all. From these, scientists select a single parameter, usually the altitude corresponding to the high-speed core of the jetstream, and run it through a long forecast. The resulting display shows a many-stranded red braid flowing like the jetstream across the planet. Initially the strands are tightly braided, but as the forecast moves out through time, they begin to diverge here and there, as differences among the models become more and more important.

Day one, for example, might show an unraveling over Los Angeles as the storm makes landfall, and another over Denver on day two, and yet another over Washington, D.C., on day four. "We use the ensemble to trace it back," says Toth. What they trace it back to are the areas of sensitivity, where more data should mean better forecasts.

How much better?

NOAA got encouraging results from the North Pacific Experiment (NORPEX), a mission flown in January 1998 by the agency's newest research aircraft, a Gulfstream IV (see "Tomorrow's Airplane," p. 67). "From 10 NORPEX flights, on average, we got improvement that is equivalent to 15 years," he says. In other words, dropsondes released during NORPEX produced the same improvement—about 10 percent—as all the data added to the national weather system in the past 15 years.

The plan today is to push westward into a sensitive area provided by Toth's computer models and to fill in some crucial blanks in the forecasters' vision of Pacific weather, then turn back and hunt for any low-level jets running ahead of the front, all while the system is still hundreds of miles at sea. The P-3 track stretches west-northwest for perhaps a thousand miles, to the 139th meridian, then turns south for several hundred miles, then back toward Monterey.

Such aerial work employs the infrastructure and data pipelines developed for tropical cyclones. As in hurricane flights, the Chief, Aerial Reconnaissance Coordinator, All Hurricanes (CARCAH), based in Miami, provides an interface between science and air traffic control. And the P-3's Hurricane Airborne Processing System, or HAPS, transmits airplane and sonde data via satellite to weather-modeling computers here and abroad. Meteorologists in Washington can use it to clarify their look into next week.

The more immediate beneficiary, however, is the Monterey Forecast Center of NOAA's National Weather Service, where the concern is what the sea will throw against the California coast in the next 24 hours. So while the P-3 serves the larger strategies of weather forecasting, its flight today is mainly a form of tactical air support, and the weather forecasters in Monterey are the infantry.

Norm Hoffman is the meteorologist in charge of a weather forecast office providing information to about seven million people, from Point Arenas, north of San Francisco, down to Morro Bay, near San Luis Obispo, where his area shades into that of the Los Angeles Forecast Office in Oxnard. Steve Martin's *L.A. Story* weatherman to the contrary, there is much to report, especially from December to April, and especially during an El Niño episode.

"This year we've seen moisture input similar to hurricanes," Hoffman says. "Can't believe the amount of moisture input. There's a realization that, yes, we do get some weather out here."

His workplace isn't the map-cluttered weather station of an earlier generation but a hushed, neatly appointed room of consoles and tidy cubicles glowing with video screens on which satellite images of the atmosphere and computer-generated weather maps germinate, bloom, and disappear to make way for another, and another.

"We get five models in here," he says, referring to the family of weather forecasts imported from computers near Washington, in the Naval Research Laboratory a few hundred yards away, and from across the waters. "Many times the computer models will predict an inch or two of precipitation. But we've sometimes observed two or three times that amount in the mountains." When Hoffman and company began seeing large differences between precipitation predicted by the highly respected Navy models from Fleet Numerical, as the Navy's modeling arm is known, and precipitation actually received, they suspected the existence of a low-level jet.

Hoffman had encountered the phenomenon earlier in Arizona and Oklahoma, and Dave Reynolds, his science officer, had detected them in the Sierras. But the jet is not easily seen. "When you run a model down to a nine-kilometer square, you wouldn't see it," he says. "Doesn't show up on satellites. Models are based on grids, and the jet apparently falls between the grid points—it's as invisible to the computer models as it is to the coastal radars and buoys. You'd need a network of low-level profilers out over the Pacific, and we don't have that."

What they do have, at least for this winter, and what few operational forecasters have ever had before, is the P-3, which they are using to shake those low-level vertical profiles out of the atmosphere. This was not, at first, an obvious solution. Sending the P-3 out to gather data for a weather forecast office, even in these heady El Niño times, was not quite right—it's a research airplane, after all, not a weather balloon. But, as things turned out, NOAA's research arm in Boulder also had an interest. "Boulder's coming in brought the airplane," Hoffman says.

But having the P-3 there for a few weeks is like borrowing a Ferrari for a weekend. When it goes home, that enhanced performance goes with it, and life is never quite the same.

Doug Miller, the dropsonde scientist on 42RF, brought along a sheaf of maps showing fingerprint-like isobars with wind arrows fluttering along them—a set for today, covering the surface and 500-millibar level (about 18,000 feet), another set for tomorrow. The maps are forecasts from a research model. Comparing winds encountered on

Today's Fleet

Besides the Gulfstream and twin Orions, NOAA fields a squadron of smaller airplanes. A favorite is N52RF, a Cessna Citation II used for aerial photography. A Turbo Commander and two Shrike Commanders are used for photogrammetry and snow-melt surveying, while two Twin Otters provide logistical support and low, slow surveys. In addition, NOAA has two Bell 212 helicopters based in Anchorage, and a McDonnell Douglas MD-500D, often used aboard fisheries research vessels.

Pilots and navigators are drawn from the agency's corps of commissioned officers, a U.S. uniformed service patterned on the Navy—except that there are no enlisted grades, and no saluting. Some of the current crop of pilots came to NOAA from the military—flying P-3s in the Navy's sub-hunting squadrons, for example—but most became aviation-qualified only after they received their commissions, at either private or military flight schools.

Only the Orions and the Gulfstream are officially named, a practice that grew out of the affection of a crew chief for his airplane. "Guy Bass, a former Air Force mechanic and flight engineer on 43RF, called his plane Miss Piggy," Sean White explains. "From that, Ron Philipsborn got the idea to call the others Kermit and Gonzo." The Orion 42RF is Kermit; the G-IV is Gonzo, "because of the big nose."

One of five scientists on the flight, Tom Shepherd keeps the flight log and monitors radar data.

NOAA technician Dale Carpenter inserts a GPS-equipped dropsonde into the release tube.

No fair-weather pilot, Ron Philipsborn takes 42RF once more into the muck.

the flight with those depicted on the maps will help fine-tune the model.

Soon, with a moaning exhalation of pressurized air, the first dropsonde goes out from a station just behind the starboard wing, with Miller, seated just aft of the tube, monitoring its eight-minute fall. These probes are the true heart of the experiment. Foil-wrapped and resembling gigantic submarine sandwiches, they are stuffed into every cranny in the fuselage, enough subs to feed an army. Inside the foil cover is a brown plastic cylinder containing sensors for pressure, temperature, humidity, and the like, together with a GPS sensor that places it three-dimensionally in space to within a handful of meters, and also reckons wind velocities around it. The whole works is called AVAPS, for airborne vertical atmospheric profiling system.

Before launch, each dropsonde is "educated" by the airplane's data banks, so that it knows who and where it is. Then, as it pops out of a pneumatic tube in the fuselage and parachutes toward the sea, it feeds a steady stream of data back into the Orion's computers and out through the HAPS to the rest of the world, in real time.

When the P-3s first came to NOAA, hardly anyone in the agency knew how to equip a research aircraft for an age of electronics, satellite data links, instant computation, and all the real-time stuff going on inside that instrument-loaded aluminum hide. There was a good deal of experience in improvising new tools of the meteorological trade, but not for something as complex as the Orions—just about everything had to be learned. Once learned, the engineers and technicians transformed the P-3s from mere high-performance turboprop airplanes into the finest airborne weather research platforms anywhere.

Twenty years later, data collection looks easy and the tools a bit dated. The gust probe, for example, used to be the only way to sample the atmosphere before it was disturbed by the airplane. Now computers can simply take the airplane out of the data, and the gust probe, as one flight engineer puts it, has become mainly a curb feeler for parking the airplane.

Today the wonderful old aircraft pounds along, now in sunshine, now in cloud, now wet, now dry; its short, rigid wings seem to soak up turbulence, like a racing car suspension. People wander the aisle, only rarely strapping themselves in. Persson buzzes up and down the fuselage, stopping to check the sonde station, then the radars. Now and then there is that melancholy hiss and cry, and another dropsonde falls toward its watery grave. After four hours, the P-3 reaches the first turning point—44.037 north, 139.056 west, at 22,000 feet; 42RF swings due south, following the meridian, and peppers the line with dropsondes.

In an hour and a half, it's time to turn back toward the east, just south of the 37th parallel. The last sonde—number 14—wheezes into the gathering darkness about 20 miles behind the front. Then the Orion itself becomes a probe, dropping to 2,000 feet as it pushes through the weather, then wheeling back to fly through it again, at 500 feet, in darkness. The descent is much like an airliner approach on a rotten day, everything obscured for a time before the ground appears. The difference is that here the ground never appears. Not at 2,000 feet, not at 500. A frothy sea can now and then be discerned. Everyone slips on a pair of waterwings.

The Orion has overtaken today's quarry, the low-level jet. It runs north-northeast, almost flush with the leading edge of the front, and it isn't like the others seen by CALJET. This one is no mighty river of moisture—it is barely 60 miles wide, and moves at only 45 knots—but it is oddly complicated. If it were alive, it would be an interesting specimen but not a new species. At the strategic scale, the flight has also done some practical good. That long westward reach into Zoltan Toth's sensitive area is going to make a difference to people in the Ohio River valley four days down the line.

Now the only outside light is the red heartbeat of the anti-collision beacon, creating a surreal vision beyond the bubble window. The big paddle blades of the propellers are strobed to a slow march through their revolutions, and the metal curves of the nacelles become the straining backs of beasts, dragging the Orion back to Planet Earth. On the nose video, the lights of Monterey await the airplane—and tomorrow's storm, which it has flown today.

Tomorrow's Airplane

As the Orions were when new, NOAA's recently acquired Gulfstream IV is the future, the airplane for which much of the past two decades of experience has been a kind of preparation. While the Orions push through the tough stuff below 30,000 feet, this ship rides the very dome of the troposphere.

The G-IV's nose is a tad bulbous, in order to accommodate an outsized five-centimeter-wavelength weather radar, and the sensor probes on its cheeks and chin look like steel whiskers, but nonetheless, this is an extremely pretty face. The machine is so gracefully configured that it seems almost to hover, as if its long, fragile-looking legs, like those of all great white birds, support no weight. The cockpit is that of a spaceship, and the eight scientific stations in the slender fuselage shine with newness.

Mainly, however, the Gulfstream is the avatar of a new era in research aviation. Its ability to fly 4,000 miles or more at between 40,000 and 45,000 feet gives scientists and their instruments a way of probing a realm too high for most aircraft, too low for satellites. Every time the Gulfstream goes out and looses a salvo of GPS-equipped dropsondes, according to Jeff Smith, who mans the G-IV sonde station, "You get some scientist saying, 'Wow, I never knew that!' "

Like its two turboprop companions, this $45 million baby was a long time coming to NOAA, and would never have appeared without some lobbying. The weak link in hurricane forecasts, NOAA argued, was predicting when and where the storms would make their destructive landfall. To strengthen that link, an aircraft was needed with enough range, altitude, and speed to take large-scale, or synoptic, data outside the hurricanes—the ambient conditions that influence the track and intensity of the storms. But the most convincing lobbyists were hurricanes Hugo and Andrew, which, in the Carolinas in 1989 and southern Florida in 1992, demonstrated how crucial an accurate landfall forecast could be.

Since the Gulfstream came aboard in 1997, however, hurricanes have provided only the airplane's summer job. It has flown research missions, including the North Pacific Experiment, devoted to finding areas where increased data can improve forecasts. This year, the Gulfstream, operating from Honolulu, and two Air Force C-130s flying out of Anchorage (as they did for NORPEX), flew winter storm reconnaissance missions, carried out in the same operational spirit—and with a good deal of the same technical infrastructure—as hurricane reconnaissance.

Although a veteran of several research and hurricane seasons, the Gulfstream is still very much a work in progress. For one thing, no one knows quite how it will behave in heavy turbulence. The first time the G-IV brushed a hurricane, recalls Commander Bob McCann, deputy director of NOAA's Aircraft Operations Center in Tampa, Florida, "there was a tendency to Dutch roll, although that could've been pilot-induced."

"At altitude," says project manager Sean White, "the G-IV is about at the limit of its flight envelope, so when you're up there and get into areas near convection or other types of clear-air turbulence, the aircraft becomes quite sluggish. It doesn't have the power to push its way through."

Nor is it stressed for the hard stuff. "The plane is rated at 2.5 Gs up and 1 G down," explains Jack Parrish, G-IV flight director and longtime hurricane hunter. "It can't take the abuse the P-3 can."

So, like a fine horse being whispered on toward more serious jumps, the Gulfstream is being introduced to severe turbulence a little at a time. Its first deliberate encounter with the phenomenon will not be down in the waves with the P-3s, but up above 40,000 feet, where a hurricane's eyewall spews an ocean of energy into the high troposphere—an aspect that, for obvious reasons, has not been closely studied.

For most flight-level measurements, the jet is comparable to the older turboprops, and its paired dropsonde stations allow it to fire veritable salvos—eight sondes can be flying at once. But the G-IV does not approach the P-3s' sophistication in such areas as cloud microphysics, atmospheric chemistry, and Doppler radar. And unlike the P-3s, it is not the kind of airplane that you just start drilling full of holes and sticking sensors on. Every new whisker and bump has to be designed into the seamless aerodynamics of the airplane.

This summer NOAA began taking delivery of instrumentation that will put the Gulfstream on a par with the Orions, but not by crowding the narrow fuselage with more metal boxes. The G-IV's extras are contained in streamlined external pods large enough for a middle-sized person to lie in. One will be fitted atop the fuselage centerline, the other two beneath the wing roots, and all will be removable in a day. The Federal Aviation Administration is expected to certify this new, ungainly look late this year; in the meantime, when this year's Atlantic hurricane season began to stir, the G-IV was still clean, and the NOAA aircraft, young and old, returned to their true vocation.

NOAA

With a 45,000-foot ceiling, a 4,000-mile range, and a 500-mph cruising speed, the Gulfstream G-IVSP introduces a new perspective—and comfort—to flight research.

For a look inside a NOAA P-3 Orion, visit the Web at www.airspacemag.com/ASM/mag/supp/AS99/Orion.html

The Man With the Plans

10,596 pages of them

by Ken Gouldthorpe

When you step into David Montgomery's tiny office in the history department of Utah's Brigham Young University, your first impulse might be to turn around, sure you had come to the wrong place. The 12- by 16-foot ceiling is aflutter with some 150 model aircraft. Though Montgomery is a professor of Near Eastern and Central Asian history, there are no leather-bound academic tomes; instead, his bookshelves are filled with row upon row of magazines, books, tattered pamphlets, and ring binders all on one subject: airplanes.

Like many of us, Montgomery was excited by aviation as a youngster, then put it aside. Grew up. Joined the army. Got a life, which included travel in Turkey, Tashkent, and Uzbekistan and advanced degrees in languages. And, like many of us, when he returned to his childhood hobby, it was with an almost fanatical intensity. But whereas some of us fanatics merely spend too much money on airplanes or hang

A man and his archive: David Montgomery with a decade's worth of airplane plans, gathered from around the world.

MARK PHILBRICK

out too long at the airport, Montgomery, with a historian's devotion to documents, has amassed a unique archive: a collection of published three-view drawings of airplanes built or imagined since the earliest years of powered flight, and some from a few years earlier.

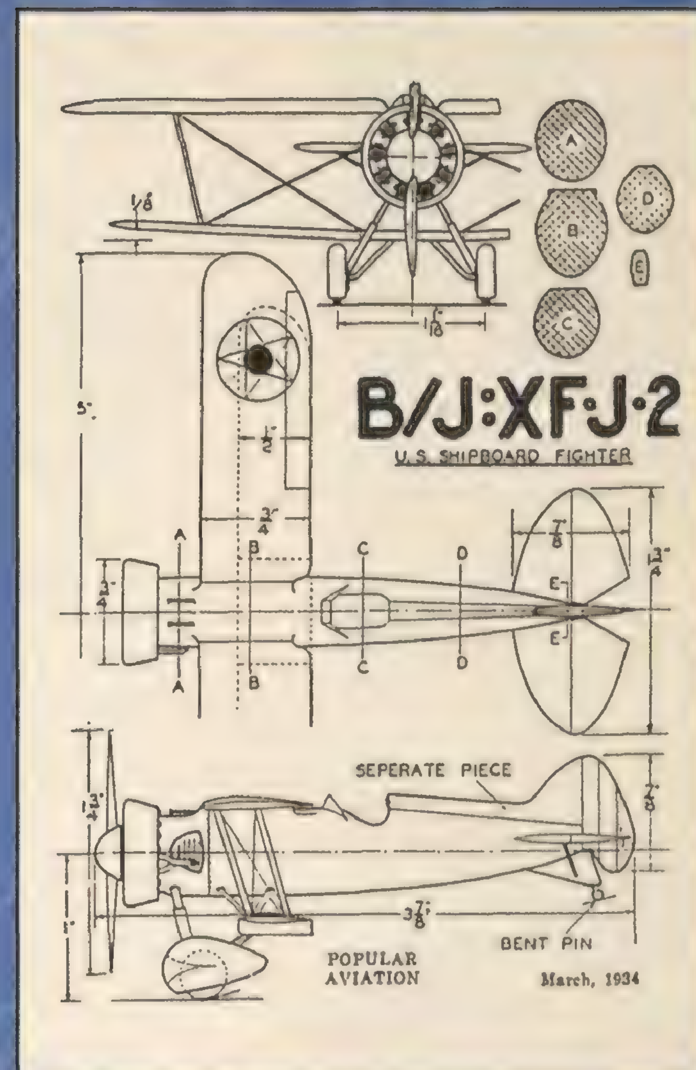
As a high school student, Montgomery had made a scrapbook of plan views. He came across it when he was about 50, looked at the collection "with a professional historian's eye," in his words, and decided to add to it—"connecting the otherwise cruddy teenage years with an adult career," he says.

He calls the project Plan View 2003, after the centennial of powered flight (and the earliest year he can retire, at age 63, from BYU). By then, his collection will be "extensive but not comprehensive," he says. So far, after nine years of work, he has collected 10,596 pages, representing more than 3,700 aircraft—a small portion of the published drawings that exist, he notes. He expects to end up with 15,000 pages documenting 5,000 airplanes by his flexible deadline of 2003.

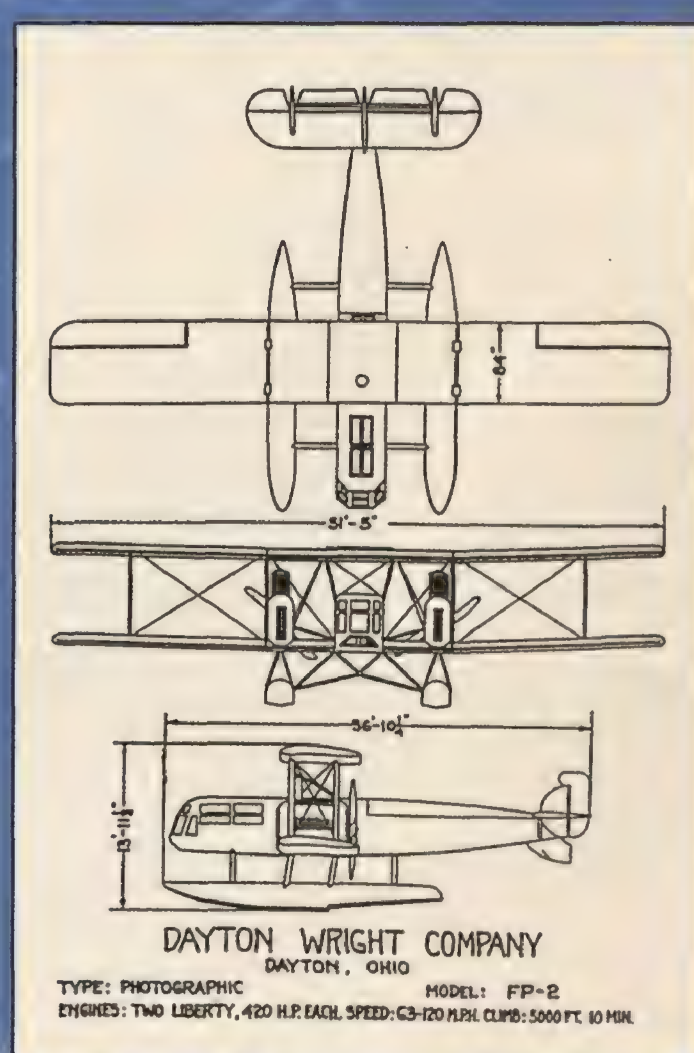
On each page appear three views of an aircraft—front, side, and top—and a block of text, identifying the aircraft and citing the illustration's source, usually a popular aviation periodical published in the last 60 or so years. Montgomery has reduced or enlarged the drawings to conform to a standard format, sorted them by country of origin, then by manufacturer or designer, then by chronological order, and stored the pages in 110 loose-leaf binders occupying almost 16 feet of shelf space in his office. It's a "visual index," he says, but also a useful bibliography to the original sources of drawings.

With a grant from BYU, he searched out plan views in the archives of Washington, D.C.'s National Air and Space and San Diego's Aerospace museums. He ran down leads on defunct publications and limited-distribution contemporary periodicals, then focused on worldwide standard journals such as the United Kingdom's *Jane's* annual aircraft series. To find aircraft plans that never made it into the standard journals, he mined bibliographies in reference books for other print sources and artists and turned to small-circulation periodicals seldom acquired by libraries, such as *Small Air Forces Observer*, a quarterly edited by Jim Sanders of the Naval Postgraduate School in Monterey, California.

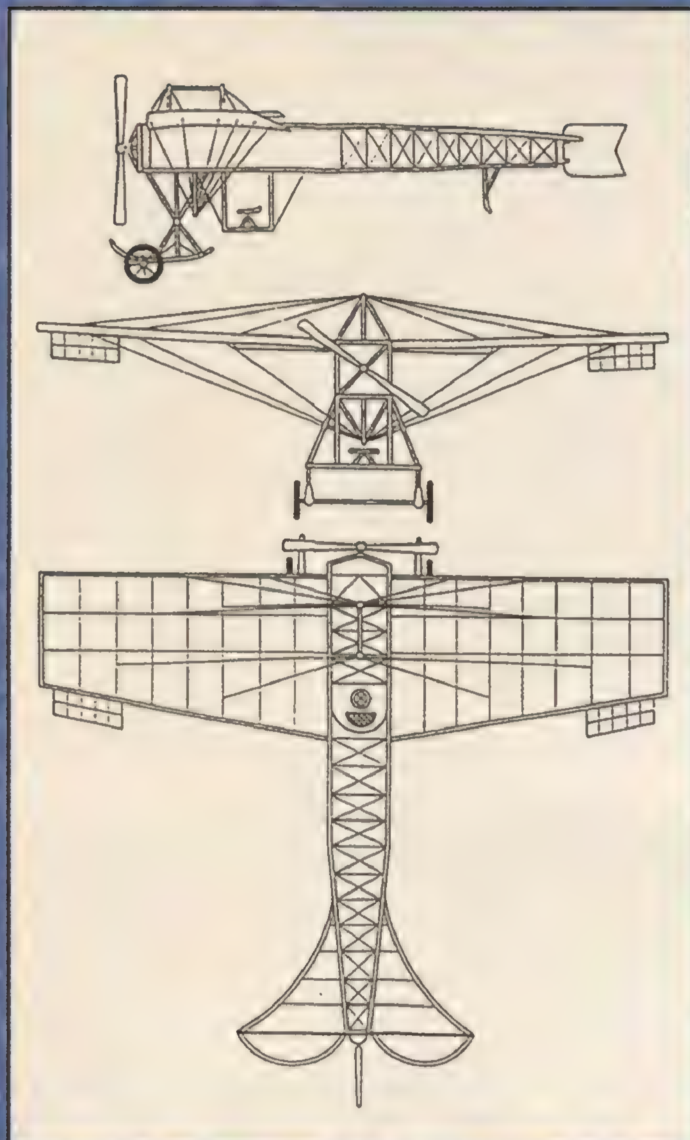
Many of these "irregular sources" came from random encounters with modelers, hobby shop managers, retired engineers, and military buffs, such as Bill Hannan, a Californian whose yearly booklet, *Hannan's Runway*, is a regular



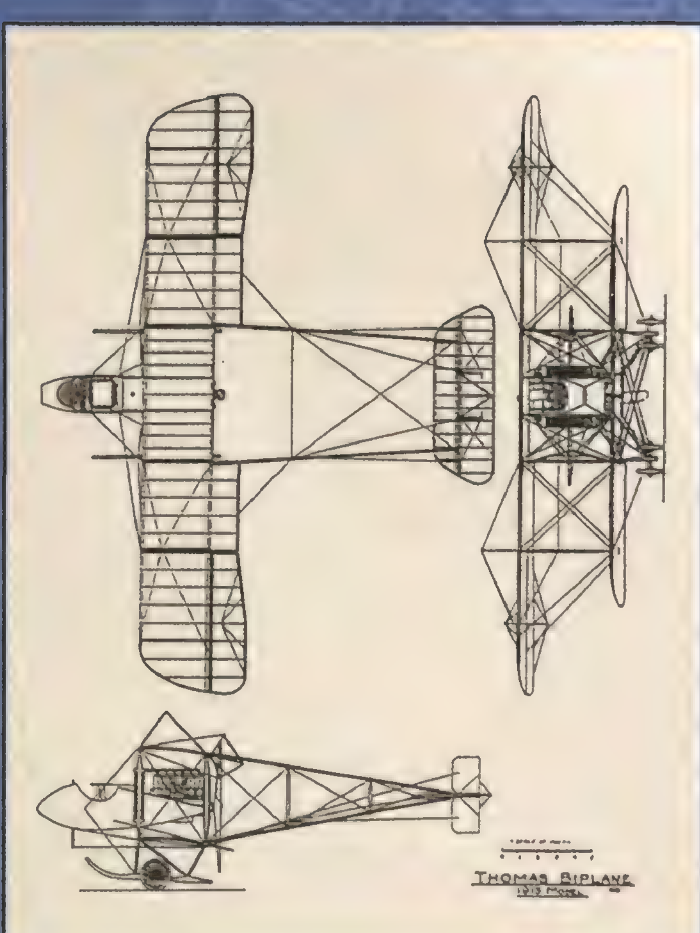
One of the first drawings found for Plan View 2003 is this three-view of a Berliner-Joyce XFJ-2 fighter, a 1931 U.S. design, appearing in the March 1934 issue of Popular Aviation. *Montgomery bought the magazine for 10 cents at a used-book store in Chicago some 45 years ago.*



From the 1922 Aircraft Yearbook *(in the Brigham Young University library), a 1921 reconnaissance aircraft, designed for the U.S. Army.*



Historian Matei Kiraly sent Montgomery this drawing of a 1911 Lacusta monoplane from a Romanian aviation journal.



Montgomery found the 1913 Thomas "Standard Biplane" in a June 1913 journal, Aircraft, *at the National Air and Space Museum.*

source. Or Andrew Anson, also of California, who publishes *AeroPlans*. Several collectors have sent Montgomery complete collections of old journals. Also generous, Montgomery sends copies of plans on request.

He has no plans to publish the collection or convert it into an electronic database, since most of the illustrations are copyrighted, but hopes to find it a home one day in a public archive. Until that time, if you want to dip into what National Air and Space Museum archivist Dan Hagedorn calls an "invaluable database," you'll have to visit the BYU history department in Provo. Exactly what would you find?

Certainly a few aircraft you've never seen before, such as the Vecihi VK.6 trainer, Turkey's first indigenous aircraft, a biplane designed by Vecihi Hurkush in the early 1920s at the end of the Turkish war for independence and first flown in 1924. Explains Montgomery, "The Ottoman empire, as decrepit as it seemed to the West on the eve of World War I, had a corps of competent engineers and designers," who were called on in 1923 when the new Republic of Turkey saw the need for replacing the imported French and British aircraft then flown by its air force. Because of the black market that developed in aircraft after World War I, says Montgomery, "it was economically more practical to purchase surplus aircraft from Italy and France," so the Vecihi trainer was never produced. Montgomery found the drawing in a book on Vecihi, *Biography of a Turkish Designer*, during a 1990 visit to Turkey, which included a stop at the country's Civil Aviation Authority.

Other plans that haven't made it into English-language publications, like those published in former Soviet-bloc countries in the 1960s, Montgomery found through personal contacts and correspondence. Matei Kiraly is an engineer and aviation historian in Romania—and the only person who responded to an ad Montgomery placed in a U.S. aviation journal a few years ago. It was a fortunate link: The two correspond and share treasures several times a year. Kiraly copies and mails new plan view discoveries; Montgomery, in turn, mails hard-to-find U.S. aviation books to the economically depressed country. In a Ukrainian journal discovered through Kiraly, Montgomery found (after years of looking) plans detailing the Tupolev ANT-9/2M, a twin-engine version of a Soviet tri-motor transport the Turks had bought in the 1930s.

He's gotten other treasures through Sven Persson, a Swedish model maker whom Montgomery met on the Internet. Persson exchanges rare European books for model airplanes.

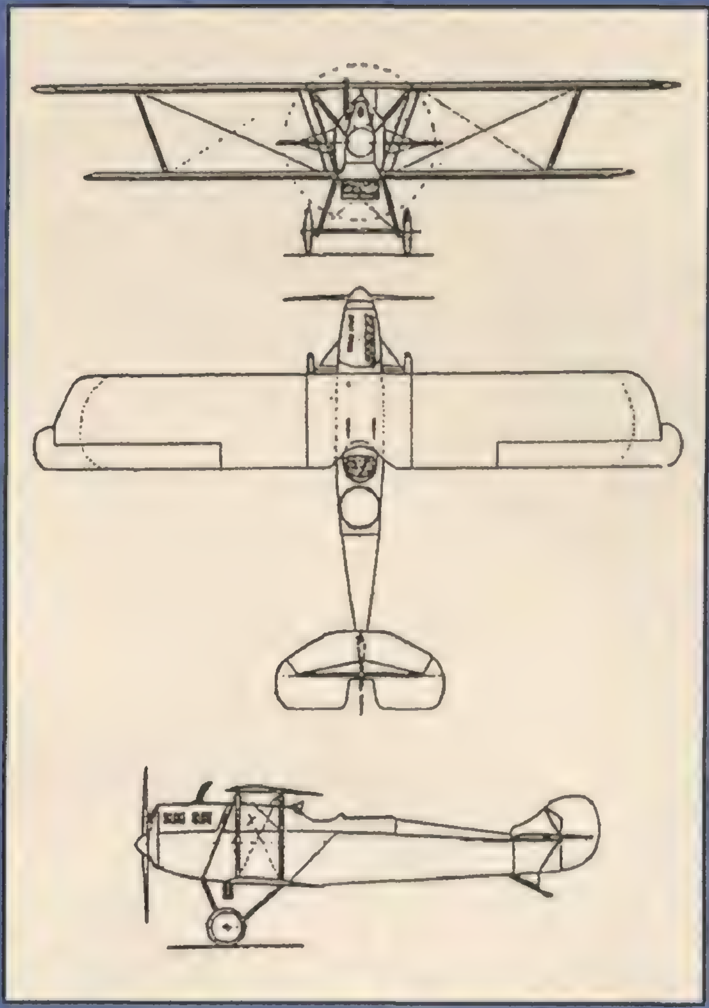
About 1,500 aircraft are represented by a single page each, including several U.S. models designed in the 1930s, when numerous contractors, like Hall Corporation and Cunningham, designed fighters for the government. Most never made it into production. Besides the plans for rare aircraft and those not available in U.S. publications, Montgomery's archive contains plans for the best-known (and -loved) aircraft. He has 48 pages of plans for the Supermarine Spitfire, that graceful, gallant fighter, first flown in 1936 and famous for protecting London during the Battle of Britain. The 40 pages represent 18 different marks, or subtypes, including the Seafire, a version designed for aircraft carriers. The U.S. Vought XF5U "Flying Pancake," with 15 pages of plans, was built in 1946 but never produced. This short-takeoff-and-landing fighter made 200 test flights and remains extremely popular among aviation enthusiasts and model builders, no doubt because of its unique shape.

Montgomery collects only the earliest published drawing of a plan but includes drawings of the same aircraft model by different artists. The archive, therefore, is an interesting collection of documents not only for aviation historians but also for students of information theory. "The most repeated items [in the literature] become popular," says Montgomery, "and initially popular aircraft are repeated, so there's a self-perpetualization of certain objects. [The Spitfire] continues to be a subject for draftsmen and modelers."

The archive also shows what was known about a particular aircraft at a certain time in history. "At the outbreak of World War II," Montgomery says, "particularly the U.S. traumatic involvement at the time of Pearl Harbor, public knowledge from newsstand sources about both Allied and Axis aircraft was very scant and erroneous, if my documentation has any valid input."

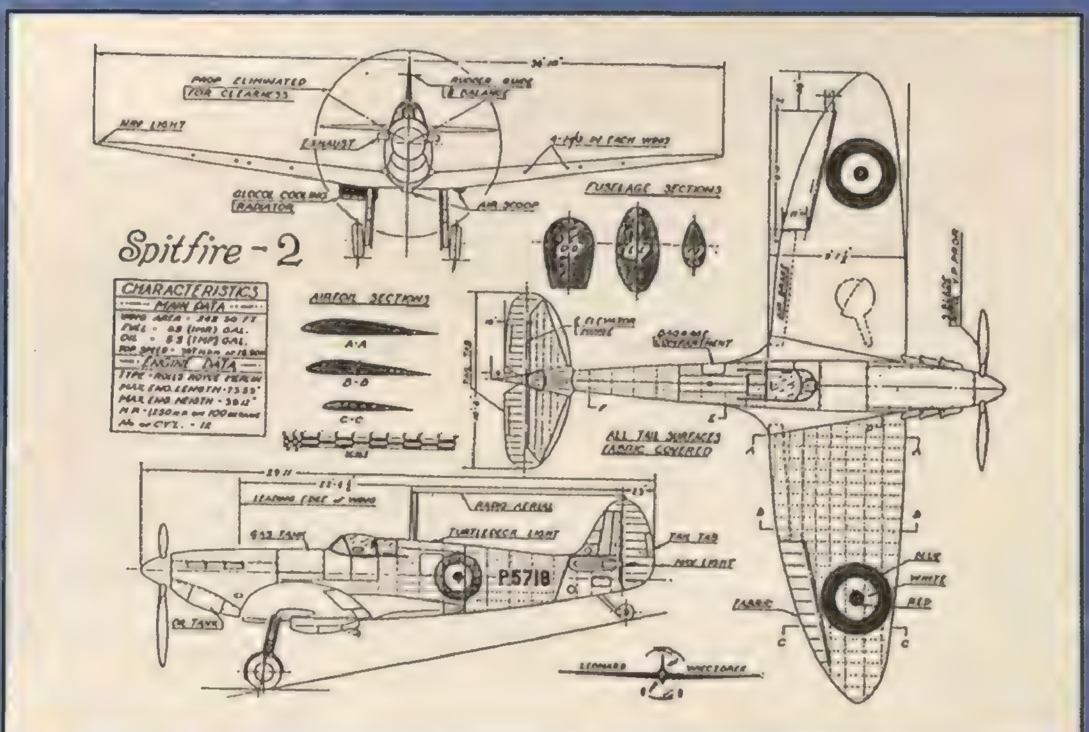
"Professor Montgomery's project is the first of its kind ever attempted," says Hagedorn. "David's not only an academic and a scholar who brings credibility to the collection, he's also an enthusiast. It's been standard for centuries in the hard sciences for flora and fauna to be studied and indexed, and here we are in a field of human endeavor not yet a hundred years old, with no tangible overall record, and where many of the pioneer aviation companies are already long extinct."

Besides being a unique contribution to a more balanced history of aviation in its first century, Montgomery's archive is a lot of fun to browse: It has just a few words and a lot of pretty pictures.



Made in Turkey: The Vecihi VK.6 trainer, powered by a Mercedes engine, never saw production.

One of 48 pages devoted to the Supermarine Spitfire, this group of drawings comes from a 1941 issue of the British journal Flying Aces.




37° 30'

Signs of Light

Why has the search for extraterrestrial life turned up nothing? Maybe we've been tuned in to the wrong channel.

by Michael Milstein *Illustrations by David Povilaitis*

Every so often, Stuart Kingsley pays to have his neighbor's trees trimmed. Where an average back yard in his Columbus, Ohio suburb holds a grill or a hot tub, Kingsley's holds an observatory, complete with a white dome about the size of a small gazebo, and he wants to make sure that the telescope inside of it always has a clear view of the sky.

Through the instrument's mirror eye and the electronics rigged to the telescope's tail, Kingsley hopes to spot what no one has ever seen before. He is searching for an extraterrestrial lighthouse—a flash of light from another solar system, another planet, another civilization.

"Once we find one," he says, "we will find others."

So far, though, his has been a lonely search, not only because he has detected no flash in the heavens but because until a few months ago, he was Earth's only lookout for an interplanetary flash.

Kingsley, an optical engineer by day, assumed this singular post with the same devotion he shows to his British homeland (the observatory sits beneath a satellite dish that links him to the BBC). His is the world's first observatory dedicated solely to a search for extraterrestrial intelligence via optical signals—identified as such on a sign he had made for the fence around his yard. His living room is lined with a bank of television screens labeled "Columbus Optical SETI Observatory Mission Control" and wired up to a nearby computer. He has organized scientific conferences on the topic, launched a voluminous optical SETI Web site (www.coseti.org), and done whatever else he can to champion the pursuit of eye-catching extraterrestrial contact.

For decades, SETI investigators conducted their searches almost exclusively with radio telescopes. That strategy has yet to pay off. Despite a few curious signals, none has met the ultimate test of repeating itself during a second close look.

This failure, plus a growing sense that radio waves may not be the best means of transmitting information through space, finally has the SETI mainstream looking for light. "Everyone's always been sort of mesmerized by radio, but we've done that experiment a lot and we're a little tired of it," says Paul Horowitz, who has led radio SETI searches at Harvard for nearly 20 years. Late last year, Horowitz and colleagues began using a telescope there to scan nearby stars for bursts of light produced by laser, which would signify planets with intelligent civilizations. Across the continent, researchers at the University of California at Berkeley are using an observatory in the hills east of the San Francisco Bay to watch for similar flashes.

The emerging optical searches, most funded at least in part by the non-profit Planetary Society and SETI Institute, are far less elaborate than the quest for alien radio beacons. But the beauty of optical SETI is that detecting a light beacon may be far simpler than detecting a radio signal.

So simple, in fact, that a dedicated amateur like Kingsley, willing to shell out a few thousand dollars for a modest telescope and computer equipment, has a chance of becoming the first Earthling to receive a message from another civilization.

Why did scientists take so long to attempt a search based on light signals? "We in SETI have always been conservative—the idea was not to go out on a limb because people were waiting to say 'That's too far-fetched,' " recalls Frank Drake, director of the SETI Institute in California's Silicon Valley. Drake, gray-haired and congenial, is SETI's founding father. In 1960 he began the first major search for alien radio signals, and later he developed the Drake Equation, a now-legendary formula for calculating the number of alien civilizations we could detect. Drake was also one of the scientists who contributed to Project Cyclops, a grand NASA-sponsored proposal, published in 1971, that envisioned the establishment of a 1,500-dish array to detect radio signals from other civilizations. (The $10 billion plan was never implemented.)

For SETI, radio waves seem in many ways a promising quarry: It takes little energy to produce them, they slice through atmospheres and clouds, and they spread out in all directions, so if another planet has as many radio and television broadcasts and radar systems as ours, it will be spilling lots of radio signals out into space, just as we do. The roughly 1,500 stars within 50 light-years of Earth have already been showered by radio waves carrying early TV shows like "Gunsmoke."

Searches for alien radio signals, though, have always faced the same dilemma confronting anyone who has tried to tune in a radio station in an unfamiliar city: Where do you start? The spectrum of radio waves alone, which dwell at one end of the electromagnetic spectrum, is a big and bustling place, far broader than the AM or FM dial.

Dial (900) HI ALIEN

Besides the search for laser signals, there's another new trend in SETI. For decades, scientists have tried to establish contact with other civilizations by listening for messages; now a private organization is preparing to send one.

Encounter 2001, a Houston company, has bought time on a 230-foot dish in Ukraine and sometime this summer will beam radio signal greetings toward one of four stars located 50 to 70 light-years from Earth. The company will repeat its transmissions in 2000 and 2001. It's a package deal; the company also plans to launch into space a capsule filled with letters and DNA samples (in the form of hair), and for $49.95, you can buy space on the capsule and also pen up to 30 words for inclusion in what the company calls its Cosmic Call.

More than 40,000 people have registered so far, says Cosmic Call Coordinator Richard Braastad, and most of their celestial correspondence has included greetings and invitations to visit Earth. A prefatory message drafted by scientists will provide basic information about Earth, human beings, and common mathematical concepts.

SETI pioneer Frank Drake and his colleagues transmitted a message from the Arecibo Radio Observatory in Puerto Rico in 1974, but otherwise Earth has shot few intentional electromagnetic signals toward the stars. Perhaps that's for the best. A look back at human history reveals that not all first encounters between different cultures were peaceful. "You might not want to shout out 'Hey, I'm here!' until you've figured out if there are some bigger kids or bullies around," says Seth Shostak of the SETI Institute. A committee of the International Academy of Astronautics has proposed that any serious attempt to announce ourselves to other civilizations in the universe first undergo international discussion. The organization plans to introduce the idea to a United Nations committee next year.

Braastad says all those who have signed up for the Cosmic Call are simply exercising their right to free speech. Cosmic communications are unregulated—anyone with a satellite dish could beam rudimentary signals into space.

In any case, the chances that aliens will hear the call and reply are "infinitesimally small," he acknowledges. If they do, though, Braastad thinks we can expect an answer in about 100 years.

Today, sensitive SETI receivers listen in on many frequencies at once. Indeed, it's not so much the Drake equation that inspires Frank Drake to believe we will detect extraterrestrial intelligence, perhaps even within our lifetimes; it's Moore's Law, a theory named for Gordon Moore, co-founder of Intel, that holds that computing power will double approximately every 18 months. While Drake's first search covered just one radio channel, or band of frequencies, today's computer-driven searches cover 100 million.

Still, the radio spectrum holds literally billions of frequencies. What about the visible-light portion of the electromagnetic spectrum? The authors of the 1971 Cyclops report assumed that any aliens out there would not bother signalling Earth with lights; such beams, they figured, would be drowned out by light from the aliens' home star and the surrounding cosmos. After all, *we* hadn't come up with any form of light that could outshine *our* sun. "Earthling imaginations are often limited by what Earthlings can do," says Dan Werthimer, a SETI researcher at the University of California at Berkeley.

"That was the nail in the coffin of optical SETI," says Kingsley, flipping through a copy of the Cyclops report with impassioned indignation. And so it came to be that for its first three decades, beginning with Drake and continuing under recent leaders like Jill Tarter, SETI listened for extraterrestrial broadcasts mainly with giant receivers tuned to radio signals, such as the 1,000-foot-wide dish in Puerto Rico's Arecibo observatory.

But even in the early days of SETI, a few scientists disagreed with that strategy. In 1961, laser pioneer Charles Townes of Bell Laboratories and colleague R.N. Schwartz suggested that Earth lasers would soon be able to produce light strong enough "to be beamed between planets of two stars separated by a number of light years." Other scientists noted it was only happenstance that human beings took up radio communications before light communications; what if another civilization had done the opposite? By now, it might be capable of producing a pulse of light strong enough to outshine its home star and thus reach us. In the 1980s, two Soviet researchers tested that pos-

Human beings took up radio communications before light communications, but what if another civilization had done the opposite? By now, it might be capable of producing a pulse of light strong enough to reach us.

sibility by initiating the first serious optical SETI search at a 20-foot telescope in Russia. But they called off the hunt after finding nothing.

A SETI program based on light transmissions has some advantages over one based on radio waves, especially when you consider the sophisticated light-producing technology known as the laser. The heart of a laser can be a crystal—ruby or garnet, for instance—a liquid, or a gas, but in any case, when the atoms in the material are stimulated, as with electricity, they will be excited to a higher energy level. As the level returns to normal, the atoms will release some of the higher energy as light.

Laser light is different from conventional, or "white" light. The latter is made up of waves of all different colors, with each color having a different wavelength. Laser light, on the other hand, is all one color and thus all one wavelength. In addition, all of the waves' crests and troughs coincide; the waves march in parallel, and thus are tightly focused. These emissions can be continuous, like the glowing beams so often wielded by James Bond's adversaries. Or they can be produced as bursts of light that are millions of times briefer than the blink of an eye.

In the latter phenomenon, when single-frequency light is chopped into pulses, many frequencies are created. At the SETI Institute, Kent Cullers prepares to demonstrate. He pushes himself away from the Braille keypad on his laptop, griping, "I hate Windows and I can't even see it." Cullers has been blind since birth, although you wouldn't know it as he drops himself into a rocking chair in his office, pulls out a Radio Shack tape recorder, and starts an audio tape of two single-frequency tones: high, low, high, low...

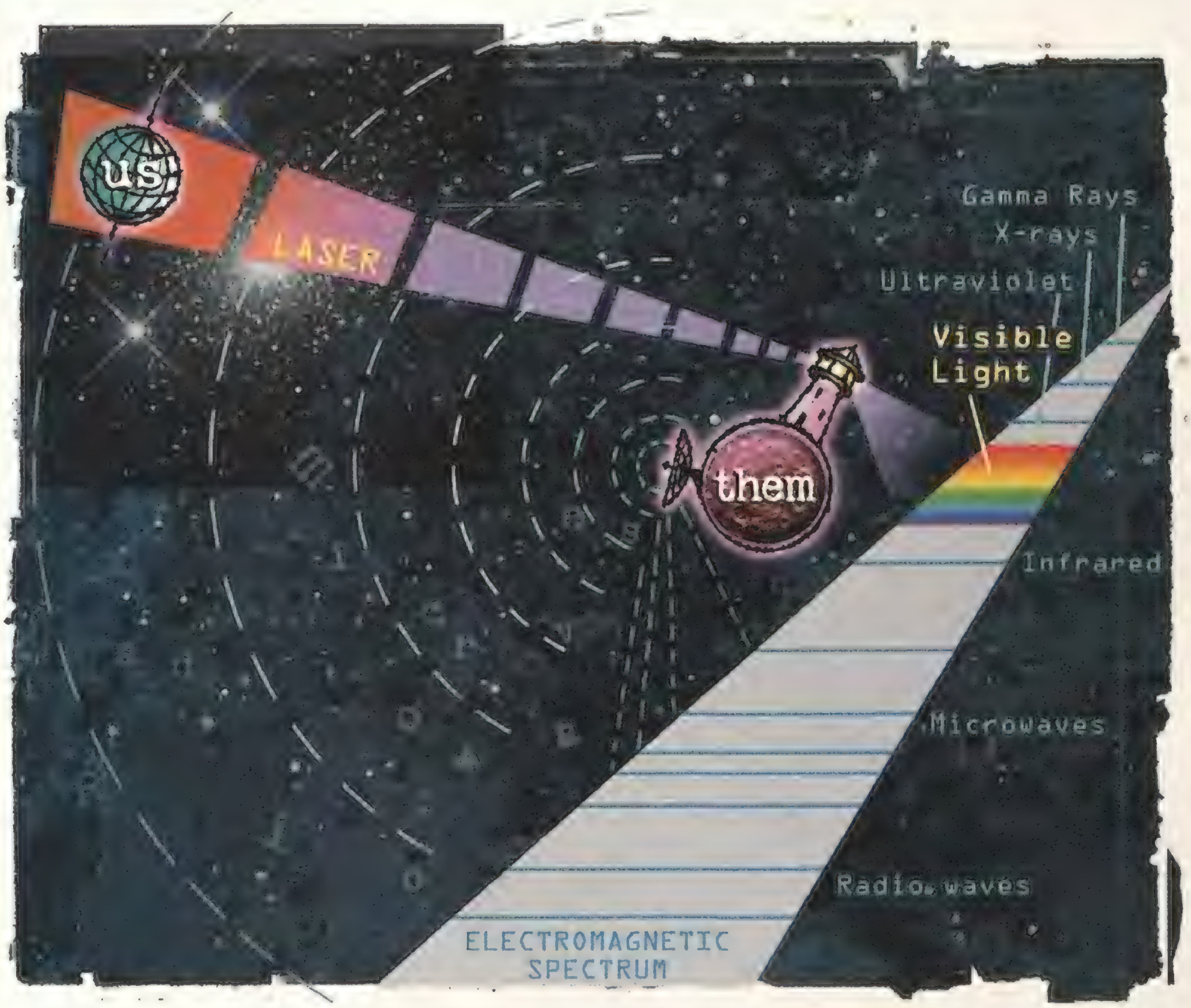
"Now listen," he says.

Gradually the tones get shorter and shorter until they are just rapid clicks that all sound alike. Cullers explains that cutting a single-frequency tone short essentially creates new frequencies, which serve to cancel the sound wave. "It's a basic physics issue," explains Cullers. "If pulses are narrow enough in time, they are wide in frequency."

Our most powerful lasers today operate the same way, though in the optical spectrum: Once their crystals have been excited, they release all the extra energy in trillion-plus-watt pulses of light lasting little more than a nanosecond (a billionth of a second). Such pulses come in loud and clear on plenty of frequencies in the visible-light portion of the spectrum, as opposed to a radio signal, which might be carried on only one radio frequency.

While our pulsed lasers cannot yet outshine our sun, in a few decades they might. And other civilizations may already have such technology. Like the signals from a lighthouse on a rocky cliff, these pulses would not carry much in the way of detailed information, but they would at least tell us that someone is out there.

Brief as such pulses are, Dan Werthimer at Berkeley and his colleagues (including laser pioneer Charles Townes, now a Berkeley professor) hope they are not too fast for the campus' Leuschner Observatory. Crowning a green hill above a tree farm, the observatory houses a 30-inch telescope, once a showpiece used to discover 26 supernovae but long since outclassed by newer and bigger instruments. "It might be the biggest telescope in Contra Costa County," Berkeley engineer Richard Treffers says hopefully as rain patters on the rusted dome. An electric space heater warms the place from frigid to chilly, and Treffers checks the bungee cord and duct tape that hold a mess of boxes, wires, and computer equipment



in place beneath the telescope's frame.

In optical SETI, the reflectors are not used for focusing on fine details of wispy nebulae or galaxies, as they are in conventional astronomy; instead, they serve as "photon buckets" for catching the light from a distant pulse.

To snag something moving at the speed of light, even buckets need fast reflexes, and at Leuschner, those reflexes are exercised in a metal box bolted to the back of the telescope.

> "If there's a big conversation going on out there, maybe space is full of criss-crossing laser beams and some will hit us."

Werthimer fashioned the detector in his basement from conventional electronic components for around $10,000. It captures and counts photons falling into the telescope. It does so not like a regular bucket, filling with more and more photons, because those from an alien laser would mix indistinguishably with all the other photons. Instead, it effectively counts photons for a nanosecond and dumps them, counts for another nanosecond and dumps them, and so on. "If it saw a pulse, you'd get a whole bunch of photons at once," Werthimer says.

When Werthimer first tested his detector, he started picking up pulses right away. That puzzled him; he couldn't be *that* lucky. Then he realized the detector's radiation sensitivity was exceeding its specificity: It was registering traces of radioactive decay coming from inside the detector itself. Now equipment splits the light from the telescope into two streams, each of which flows into an identical detector in the metal box. If only one registers a signal, it's likely an errant one, originating within that detector; if both register a signal simultaneously, Werthimer might have something.

Werthimer has recently begun using the Leuschner telescope to spy on the first of about 2,500 stars that are considered about the right temperature and the right age—at least a few billion years old—to nurture life now capable of communicating. It will also look in on a few other galaxies and globular clusters. The telescope will collect photons for a few minutes, then move on to the next star, alerting Werthimer and his crew if it spots any sign of a pulse.

At Harvard, Paul Horowitz is doing similar work with light that other astronomers have collected but didn't need for their own observations; he is funneling this excess light into slightly fancier dual photon detectors. So far, about 100 simultaneous flashes have been detected, but none has appeared on a second look, suggesting that Harvard's photon bucket is collecting occasional cosmic rays.

Horowitz is now considering a search that would pair the Harvard telescope with one at Princeton University in New Jersey. Just as Werthimer's two photon detectors cross-check each other, the two telescopes would be trained on the same star simultaneously, and a computer could be programmed to discount cosmic rays. If they both picked up a pulse, Horowitz says, "we go berserk."

As a communication device, the preeminent strength of lasers is that the light they produce is tightly focused and thus easy to aim. "Optical is not scattered like radio," Horowitz says. "It cuts through space like a hot knife through butter." But when it comes to SETI, that feature is laser light's preeminent weakness. Because the beam is so narrow, it can be blocked by interstellar dust. In addition, the narrowness would require another civilization wanting to reach us to aim its laser carefully, which would in turn require it to know enough about us and the continuous movement of our solar system to predict where we would be after the many years needed for laser pulses to cross the vast distances of space. Either that, or Earth would have to serendipitously drift into the line of fire of lasers shooting between other civilizations scattered among the billions of stars in the galaxy. "If there's a big conversation going on out there—like Carl Sagan said, 'a galactic Internet'—then maybe space is full of criss-crossing laser beams and some will hit us by mistake, like a laser would zap a bug in a planetarium during a laser light show," says Geoffrey Marcy, a San Francisco State University physicist.

Marcy and colleague Paul Butler may be the world's best-known planet hunters: By discerning subtle shifts in various stars' optical spectra, they have so far spotted around a dozen planets circling. When it comes to other stars, they now believe planets are probably the rule, not the exception.

That sounds like the kind of conclusion that would only encourage SETI boosters. According to Frank Drake's famous equation, a large number of planets, among other factors, increases the number of alien civilizations we could detect. And yet, as we have looked farther and farther out into the heavens, as we have listened for radio signals year after year, we have neither seen nor heard any convincing evidence of an alien civilization.

SETIologists offer plenty of explanations: Maybe we have been quarantined ("with good reason," Marcy quips). Maybe our location, on the fringe of the Milky Way, has put us outside the range of Milky Way inhabitants who are signalling one another. Maybe advanced civilizations communicate with fiber optic cables and thus don't leak light signals. Maybe their waves cannot punch through our atmosphere. Maybe we just haven't invented the right detectors.

Maybe no one's out there.

"I've spent thousands of hours at major professional telescopes, and I've never once seen anything even remotely suggesting extraterrestrial intelligence," says Marcy, who counts SETI veterans Werthimer and Jill Tarter as good friends ("We go salsa dancing together"). "With all our searching, we have received no results in abundance. Some people say, 'Well, that doesn't prove anything,' and they're right. You can't prove there's no intelligence out there. But does it say something? Yes, it says that intelligence may be less common than we had hoped."

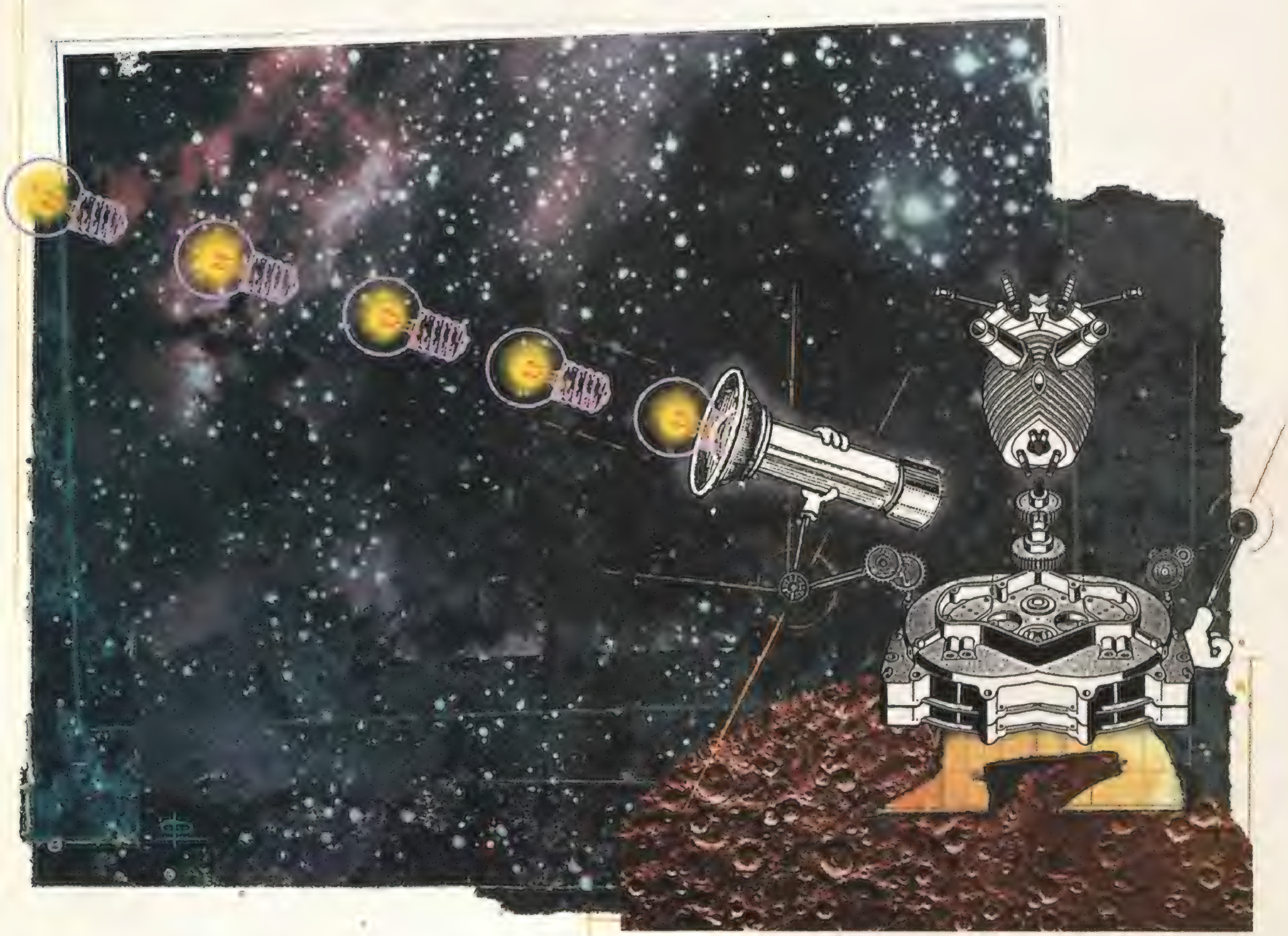
Nonetheless, one of Marcy's graduate students, Amy Reines, is now writing computer programs that will look for the signature of an alien laser in some 400 computerized spectra Marcy and Butler have collected in their

planet search. They use spectrometers to spread light from distant stars into spectra. Although the scientist in Marcy doubts he will ever see the sign of an alien laser, the wonderer in him hopes that Reines' relatively inexpensive project might reveal the unexpected. "It's a long shot, an incredible long shot," he says with a pleasant intensity that says he revels in the unlikely.

It is a testimony to the allure of SETI that such dreams flourish even after decades of futile searching—that the lack of success so far is leading researchers to branch out, not only into the optical spectrum but also beyond. Indeed, the importance of the search for light may not be the results it produces but the fact that it signals a renaissance in the larger search for extraterrestrial intelligence. Booming computer power, low-cost technology, increased public enthusiasm, and open-minded innovation are today recharging the ambitions of a once politically battered program that NASA disowned in 1993. There are new visions for the effort: searches for infrared signals, full-time optical SETI observatories, big radio dishes in space and on the moon ("There's a crater on the backside of the moon that would be perfect," Berkeley's Dan Werthimer says dreamily). There's even a plan afoot to try sending some signals of our own [see "Dial (900) HI ALIEN," p. 74].

Not everyone is so optimistic. Benjamin Zuckerman, an astronomer at the University of California at Los Angeles, carried out his own search for alien radio waves from 1972 to 1976, and he now considers the exercise to have been a complete waste of time. A search for life capable of transmitting radio or light signals is simply too narrow-minded, he says, too egocentric. "They're so fixated on this one type of life, they're basically throwing out the idea of any other life," he says. If an alien society had conducted such a search only 100 years ago, he points out, it would have missed Earth completely.

But if there *were* another form of life out there, and it *could* send light signals...? Even an optimist like Stuart Kingsley admits that if his backyard observatory someday spots a laser pulse, he would, in a way, be disappointed. Despite all the visions of Star Trek (Kingsley is a big fan) and Star Wars and Buck Rogers, the signalling of another civilization may carry a message besides "We are out here." It might also mean "This is the best we can do," and actual travel among the stars is impossible. At least for now.



SIGHTINGS

When Los Angeles photographer Bob Seidemann began photographing aircraft, his appreciation of their beauty led him to ponder the talents of their designers. "If airplanes are art, then the people who made them are artists," he says.

Bringing more than 80 designers and their machines together for photo shoots over the last 10 years required persistence, luck, and patience. Seidemann kept himself on call in 1991, for example, until a frail but eager Maynard Pennell felt well enough to spend a few minutes on the tarmac with the Boeing 707 prototype he designed (above).

Chance intervened, as well. In 1990, while Seidemann was in London for an airshow, he asked a stranger for directions. The stranger was General Vladimir S. Ilyushin, a former chief designer and test pilot of the Sukhoi Design Bureau and the son of celebrated aircraft designer S.V. Ilyushin. Two weeks later, the two met in Moscow with a prototype of the Su-100, a titanium-clad, Mach 3-plus bomber (opposite) based on the North American XB-70 (see "The Legend of the Valkyrie," p.46).

In 1989, Seidemann waited months to photograph a very busy Paul B. MacCready (right), designer of solar-powered vehicles and the first human-powered aircraft to cross the English Channel. Seidemann learned about MacCready from another subject: Ben Rich, a lead designer of the Lockheed F-117A stealth fighter. "So the highest-tech guy gave me the lowest-tech guy," he marvels.

Much Amiss Aboard Mir

Dragonfly

by Brian Burrough. HarperCollins, 1998. 528 pp., $26.95 (hardcover).

Astronauts are cool, risk their lives, fly billion-dollar machines at thousands of miles per hour, and bear the responsibility if things go wrong. Astronauts get the ticker-tape parades and the Corvettes and the chicks.

At least that's the way it's portrayed in *The Right Stuff.* There haven't been many popular books written about today's astronaut corps because, for the most part, they're a tame bunch. The typical astronaut now has a Ph.D. in astrophysics, eats health food, and is a good family man or woman. Pretty boring.

Bryan Burrough's *Dragonfly* is about the recent visits by shuttle astronauts to the Russian Mir space station, and focuses on the astronauts themselves. They're a diverse and interesting bunch—personalities instead of just smiling faces at media events—but for the most part unwilling to voice concerns about how dangerous Mir had become. Mir offered an opportunity to gain experience with long-duration spaceflight, but it also was plagued by fire, a collision, and repeated computer and hardware failures.

Even more interesting than the astronauts are some of the characters behind the scenes, such as George Abbey, former head of the astronaut program and current head of NASA's Johnson Space Center. Stay in Abbey's good graces, Burrough reveals, and you can fly into space. Fall from grace, and you remain on the ground.

Burrough's portrait of NASA isn't a pretty one, as safety became less important than the public relations value of flying on Mir—which meant that only an astronaut willing to sacrifice his flying career could speak out. Brian O'Connor realized he would never get another shuttle mission about the same time he was appointed head of a key safety office at NASA. With nothing to fear, he spoke out about the conditions aboard Mir, and Burrough was there to listen.

Dragonfly is the most important space book to be published in a decade. It isn't the best, nor even the best written: In those categories it is outranked by Andy Chaikin's *A Man on the Moon* and Charles Murray and Catherine Bly Cox's seminal *Apollo: The Race to the Moon*, respectively. *Dragonfly* is important for what it says about the inner workings of NASA and for its insights into modern astronaut culture.

The book is not without flaws (cosmonaut Gherman Titov would be interested to learn that he's dead), but they are largely unimportant. Burrough did his homework, and had incredible access to NASA—which many at the agency now regret.

—Dwayne A. Day is a writer on space policy and history.

NASA

Night Fighters Over Korea

by G.G. O'Rourke and E.T. Wooldridge. Naval Institute Press, 1998. 224 pp., $34.95 (hardcover).

When the Korean war broke out, the "Nightcappers" of Navy Composite Squadron Four—VC-4 for short—were orphans; the Navy didn't know what to do with them. Jet fighters were mostly single-seat, single-engine craft with sleek lines and snappy performance, but the outcast Nightcappers flew a big slow tub, the Douglas F3D Skyknight.

Meant to battle enemy aircraft during the nocturnal hours, the Skyknight carried a pilot and radar observer, side by side, and was supposed to fly from a carrier deck. But when VC-4 embarked aboard USS *Lake Champlain* (CVA-39),

the sea and the Skyknight did not agree. Searching for something to do with this unusual squadron and its unusual aircraft, the Navy plunked both down at the backwater airfield known as K-6 in P'yongtaek, South Korea.

Night Fighters Over Korea is Captain Gerald G. "Jerry" O'Rourke's account of how a small band of aviators with an unconventional mission went to Korea and took command of the night. E.T. "Tim" Wooldridge, who served in numerous capacities at the National Air and Space Museum, collaborated with him and completed the volume after O'Rourke's death in 1997. The result is a touching first-hand account with an authoritative ring.

At P'yongtaek, VC-4 was folded into Marine night fighter squadron 513, abbreviated as VMF(N)-513 and dubbed the Flying Nightmares. In this early cooperative effort, which presaged today's joint warfighting, Navy and Marine fliers shared the job of prowling the Korean darkness where the nimbler, faster MiG-15 lurked. Ultimately, VMF(N)-513 was credited with shooting down no fewer than 12 enemy aircraft, including the first jet aircraft ever destroyed through the use of a fighter equipped with airborne intercept radar. No enemy fighter scored any aerial victory in return during the entire Korean war.

Pilots often write in technicalities, but O'Rourke's writing is free of jargon. The F3D Skyknight "was built like a transport. Its straight, fat wings were great for takeoff, for turning, and for climbing at slow speeds, but they would really balk at any try to get above a speed of about 0.75 Mach. Even when going straight downhill, the intense wing drag would rarely let you get beyond 0.78 or 0.80 Mach, and at that speed the tail would quit working and you'd lose most elevator control until you descended into much thicker air."

To enter the Skyknight on the ground, you "slid back a flat square glass door and dropped down into a spacious cavern that seemed more like a control room than a cockpit."

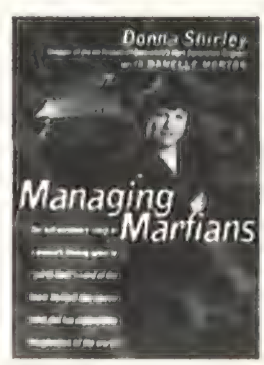
Night Fighters Over Korea is a small book with a Skyknight-size price tag. The selection of photos is good, but could have been better had the authors turned to additional sources that are readily available. There is little to nit-pick in the text, although the authors perpetuate the myth that the F-94B was called the Starfire, a name that was coined later for the post-Korea -C model.

Almost half a century after Korea, doctrine and tactics have undergone a massive revolution. In our brave new world, American forces fight at night. When Jerry O'Rourke was doing it, he was a pioneer. *Night Fighters Over Korea* is a readable, informative, overdue account of a superb contribution by dedicated fliers.

—Air Force veteran Robert F. Dorr is co-author of The Korean Air War *(Motorbooks International, 1994).*

Managing Martians

by Donna Shirley, with Danelle Morton. Broadway Books, 1998. 320 pp., $25.00 (hardcover).



Mars fascinates. The red speck in the heavens whispered to the ancients and sings to us. Donna Shirley felt the call of the Red Planet from a tender age, and then, in storybook fashion, found her way there as manager of NASA's Mars Exploration Initiative and manager of the team that built the Sojourner Truth rover, the plucky, microwave-oven-size star of the summer 1997 exploration of our solar system neighbor. In this autobiography, she shares her bumpy progression from youthful dreamer to a leader of this gritty, improbable triumph.

Her path through life seems the stuff of Hollywood, a parable of the determined individual surmounting social obstacles and the occasional personal blunder. Sexual politics illuminate the stages of Shirley's life—her middle-class upbringing in Oklahoma farm country; her early, "unladylike" passions for flying, mathematics, and science; life as a collegiate curiosity—a female engineering major at the University of Oklahoma; and then work in the male-dominated ranks of aeronautical engineers, with a career of more than 30 years at NASA's Jet Propulsion Laboratory in California.

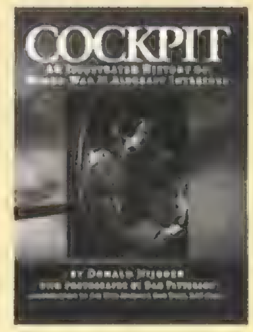
At Oklahoma she was one of only six women engineers; when she joined JPL in 1966 she had even fewer counterparts. When Shirley assumed leadership of the Mars Rover program in the early 1990s, it was the first time in NASA's history that a woman had been given program manager's responsibility for spaceflight hardware—the benchmark of status in the agency. Her reception in engineering circles was often chilly and not infrequently misogynistic. But her story never devolves into an accusatory battle of the sexes.

While the motif of gender is rightly prominent, Shirley emphasizes her work as an engineer and manager. The bulk of her account focuses on challenges of gaining acceptance for and designing the diminutive Rover. Shirley began work on robotic rovers for Mars more than a decade before the famous meanderings of Sojourner Truth. During that time, old ways of doing business at NASA were slowly giving way to new. For reasons of politics and prestige, NASA engineers and managers preferred big-budget, big-satellite, complex science missions. But as budgets tightened and spectacular failures occurred, the mantra "faster, better, cheaper" came down from the top. Shirley and her team rode this unsteady wave of institutional change (still under way in the space agency) to go from a sports-utility-size rover to the rough-and-ready Sojourner, using clever designs, advances in computing technology, and off-the-shelf commercial components. In the process, Shirley developed a cooperative style of management (akin to Japanese models in vogue) to foster creative problem-solving and adapt to institutional change, and drew in part from her experiences as a woman engineer to create a climate of equality and respect within her team.

To those watching the news conferences of July 1997, the marvel of Pathfinder and Sojourner Truth making it to Mars was inseparable from the smart,

COCKPITS

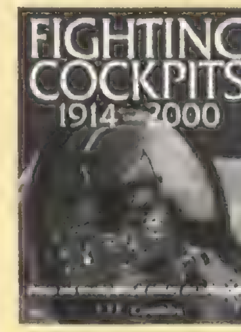
Cockpit: An Illustrated History of World War II Aircraft Interiors



by Donald Nijboer, with photos by Dan Patterson. Howell Press, 1998. 176 pp., color and b&w photos, $39.95 (hardcover).

Dan Patterson has a knack for lighting aircraft interiors. As you thumb through this book, you'll swear you can smell oil and av-gas. Features crisp, full-page photos of the interiors of 37 World War II aircraft.

Fighting Cockpits 1914–2000



by L.F.E. Coombs. Motorbooks International, 1999. 185 pp., color and b&w photos, $39.95 (hardcover).

Fighting Cockpits offers a scholarly look at how black dials have given way to multi-function displays in the modern fighter. Includes detailed discussions of both the ergonomics and the electronics involved in ejection seats, head-up displays, and more.

Falcon 4.0 by MicroProse. (800) 400-1352, www.microprose.com, $49.99.

When it was released in 1991, *Falcon 3.0* was hailed as one of the most advanced games of its day: a third-generation air combat simulation designed to portray the awesome capabilities of the F-16A. Seven years later, MicroProse and Hasbro Interactive have taken this classic to dizzying heights, basing its latest design upon the superior F-16C Block 52 aircraft in service today.

Like its predecessor, *Falcon 4.0* offers a head-to-head Dogfight mode and a full-feature mission builder that includes 31 training missions. *Falcon 4.0* also includes three campaign games based upon a second Korean Conflict occurring in the not-too-distant future. All the campaigns are dynamically constructed, which in effect means that each Air Tasking Order is determined by the player's performance on preceding missions. There's also an Instant Action mode, in which players can take to the skies against various adversarial aircraft without having to worry about the bigger picture.

In addition to a comprehensive online reference guide, *Falcon 4.0* sports a recorder mode that lets players review their missions. The avionics suite has been superbly represented and the aircraft and terrain engine offer eye-popping visual effects that are sure to set a new benchmark in computer simulations.

F-16 Multirole Fighter by Novalogic. (818) 880-4997, www.novalogic.com, $49.99.

Novalogic has earned a reputation for creating some of the most diverse combat simulations imaginable, games that typically emphasize action-packed worlds at the expense of scale and precision. *F-16 Multirole Fighter*, their latest air combat simulation, breaks from tradition—it's designed to appeal to the entry-level player and the ardent enthusiast as well.

Developed in association with Lockheed Martin and released to coincide with the debut of another game, *MiG-29 Fulcrum*, *F-16 Multirole Fighter* was produced as one of two fully compatible air combat simulations that could be played as stand-alone products or against one another in head-to-head competition. In addition, both games can be played online for free through Novalogic's newly launched Integrated Battlespace System—an Internet-based multi-player environment that can accommodate as many as 120 players in one arena.

In addition to an innovative zoom-in/zoom-out head-up display, *F-16 Multirole Fighter* showcases Novalogic's all-new 3-D interactive virtual cockpit: a stylized instrument panel that lets players examine and/or activate any onboard system with either a simple mouse click or a keystroke command. In terms of game play and overall performance, the simulation is downright impressive, boasting dazzling visual effects, stunning landscapes, and an incredibly realistic and detailed physics-based flight model. For instance, as a simulated aircraft burns off fuel or drops ordnance, its handling characteristics change, making it much easier for the pilot to maneuver. To determine aircraft performance, the exacting flight algorithm even takes into account air pressure, engine efficiency, fuel flow, dynamic mass, and outside temperature. While it still doesn't compare to *Falcon 4.0* for sheer depth of play, *F-16 Multirole Fighter* is nevertheless a worthy addition to any air combat enthusiast's gaming collection.

F-16 Aggressor by Bethesda Softworks. (301) 926-8300, www.bethsoft.com, $39.99.

Developed by British-based General Simulation Incorporated and published in the United States by Bethesda Softworks, *F-16 Aggressor* takes a far different look at how F-16s might be used in the wars of tomorrow. Instead of serving in some country's national air force, each player is thrust into the role of mercenary pilot, who, under the employ of several beleagured African governments, must attempt to rid the continent of various insurgents.

The 40-mission campaign game moves around Africa, opening over Morocco and culminating on Madagascar. After successfully completing a mission, the player receives recompense for his services, which, in the original version, could then be used to purchase a wide array of sophisticated weaponry; unfortunately, in later versions the compensation is worthless. In addition to the rather lengthy campaign game, several different training missions are offered as well as an instant-action Scramble mode, in which pilots can fly in any of the regional theaters.

In terms of aesthetics, *F-16 Aggressor* is on a par with the other F-16 simulations profiled here, featuring attractive aircraft exteriors, realistic instrument panels, and lush terrain to fly over. However, from a game playing standpoint, *F-16 Aggressor* trails off rather quickly, due in part to the over-simplified avionics suite and the somewhat arcane premise. Unless you're thinking about becoming a gun for hire, you'd be wise to set your sights on the other sims.

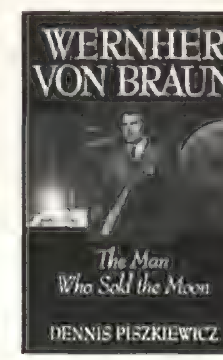
—Marc Dultz is a freelance computer simulation reviewer.

impassioned, funny expositions of team members from around the country as the next bits of exploration, new scientific data, and photos rolled in. The experience seemed so exuberantly American. So too does Donna Shirley's story of how one dreamer, irrepressible and determined, helped us all enjoy that moment.

—Martin Collins is a curator in the space history department at the National Air and Space Museum.

Wernher von Braun: The Man Who Sold the Moon

by Dennis Piszkiewicz. Praeger Publishers, 1999. 288 pp., $27.95 (hardcover).



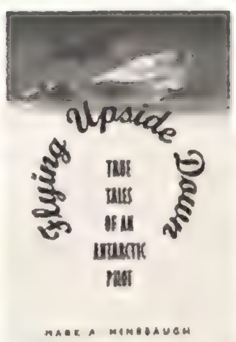
Wernher von Braun will be forever controversial. To a dwindling band of followers, and to many space enthusiasts across the generations, he remains a great American visionary—the man who got us to the moon. To the survivors of the Mittelbau-Dora concentration camp, and to a growing band of critics, he will be remembered first as a Nazi, even as a war criminal. For decades, his supporters had the upper hand, propagating only the official version of von Braun's career in the Third Reich. The focus of Dennis Piszkiewicz's short biography is the creation of this official history and its slow crumbling before and after von Braun's death from cancer at age 65 in 1977. Particularly since the 1980s, journalists and academic historians have turned up many details about von Braun's memberships in Nazi organizations, including the SS, and his dealings with concentration camp labor.

Unfortunately, Piszkiewicz's book does not fill the need for a full-scale, balanced biography of the man. Although clearly written and not without shrewd insights into von Braun's career and celebrity in the United States, *Wernher von Braun: The Man Who Sold the Moon* is far too short and superficially researched to do him justice. The book depends almost entirely on the secondary literature in English, and not always the best of that; Piszkiewicz cannot read German, so parts of the book are quite unreliable and error-ridden. The author's coverage of von Braun's life in America after 1945 is better, but superficial. He is best on the public aspects of the man's career, especially a famous series in *Collier's*

magazine and a collaboration with Walt Disney, both of which did so much to popularize space travel in the 1950s. He also turns up a couple of tantalizing tidbits from FBI files. But he says little about von Braun's crucial role in the management of Army missile and NASA space programs because little of substance is available in the sources he has consulted. Even for a short, popular biography, the book is unsatisfactory. But for those who are deeply interested in von Braun's career, Piskiewicz's book may be worth a look, as it points in the direction toward which a full-length, critical biography must go.
—Michael J. Neufeld is a curator in the space history department of the National Air and Space Museum.

Flying Upside Down: True Tales of an Antarctic Pilot

by Mark A. Hinebaugh. Naval Institute Press, 1999. 312 pp., $29.95 (hardcover).



"Antarctica. The white continent. The 'Ice.' It is the coldest, highest, driest, windiest, most isolated, and most desolate of places, by turns inspiring and daunting." So starts naval aviator Mark Hinebaugh's excellent reminiscence of flying in Antarctica.

"Great God this is an awful place," wrote another Antarctic visitor, Robert Falcon Scott, on January 17, 1912, as he faced an icy death. Hinebaugh sprinkles his writing with quotes from the journals of Scott and the other early Antarctic explorers. As he and his crew are challenged daily, his knowledge of the fate and hardships of those who went before are foremost in his mind.

As he flies his ski-equipped LC-130 Hercules over the mountains, glaciers, and ice shelves to arrive at the Pole in less than five hours, Hinebaugh cannot help reflecting on the more than two months it took Scott's party to reach the pole. Thanks to modern technology, it is possible for the National Science Foundation to explore the vast Antarctic regions from October to March, during the austral summer. Because Antarctica has a landmass larger than the United States and Mexico combined, the responsibility to transport and supply the many remote teams studying the vast continent, under an agreement between the NSF and the U.S. Navy, fell heavily on the shoulders of the men and equipment of the Navy's VXE-6 Squadron, with their reliable Hercules and the UH-1N Huey helicopters. Responsibility for the mission

was recently transferred from the Navy to the New York Air National Guard.

Hinebaugh's engaging book covers three six-month tours on "the Ice." He recounts the high stress of flying in a hostile environment, where the temperature dips to –94 degrees Fahrenheit and winds exceed 200 mph. These sudden onslaughts are referred to as Herbies, and while the name is cute, the storms are deadly. Sudden changes of lesser intensity, but no less hazardous to flight, are capable of dropping visibility from acceptable to unflyable in a matter of minutes.

A runway is maintained at McMurdo for large conventional transports to fly in mail and supplies, but the other runways in Antarctica have to be made by the Hercs, dragging their skis on a low pass across a suitable-looking area. Operating from skiways offers its own set of unique challenges, and demands skillful handling of the often overloaded Hercs. Hinebaugh's descriptions of how a crew works together to give cues to the pilot in low-visibility landing conditions will keep you turning the pages.

While telling us about the flying, Hinebaugh also describes the aesthetics of the Antarctic, including the beautiful sunsets. His description of a few days in Christchurch, New Zealand, had me contacting my travel agent. He deftly shifts into these surprising passages of description, then into the strong, bawdy language of aviators when relating his disdain for the incompetence of the weather forecasters, an arrogant "Nova" TV crew, and the supercilious PIs (scientific principal investigators), and his special dread of the "Goat Ropes," officially referred to as VIP tours. However, not all is serious. Saturday night parties take on special significance in the long weeks of hard work and isolation, leaving many memorable tales in their wake. In some weather situations, just getting the airplane down safely is reason enough to break out the champagne and celebrate.

Flights over the majestic mountains, ice rivers, and massive glaciers put you in the pilot's seat. I recommend making a copy of the Antarctica map from the book's introduction, for ready reference in tracing Hinebaugh's flights.

Flying Upside Down is an excellent book of flying adventures and a first-hand look at demanding operations in Antarctica. I found myself almost wishing I could fly a tour on the Ice. Almost.
—Lieutenant Colonel Bob Hanson, U.S. Air Force (ret.), is a career fighter pilot who flew C-47s and C-119s during various low points in his career.

CREDITS

Thirty Seconds Over Philmont. Arnold Benson is a frequent contributor to *Air & Space/ Smithsonian.* He is toying with the idea of climbing back into an A-26 at an upcoming airshow.

Upstaged. Bob Brodsky, now retired from TRW Space and Technology and the University of Southern California, is writing his memoirs.

Getting the Picture. A writer specializing in the space program, Henry S.F. Cooper Jr. is the author of eight books.

Further information: Visit Malin Space Science Systems on the Web at www.msss.com.

Remnants of Glory. New York City-based photographer and writer Russell Munson jumps at any opportunity to fly across the country. He has owned his Piper Super Cub for 32 years, and if he decides he likes it, he'll probably keep it.

The Coffee Royal Scandal. Lise Pyles is a freelance writer who covers aviation, Australiana, and history.

The Legend of the Valkyrie. John Sotham is an associate editor at *Air & Space.*

John Batchelor, a devotee of fly fishing, has illustrated postage stamps for 38 countries.

Further reading: *Post-Word War II Bombers,* M. Knaac, Office of Air Force History, 1988.

A History of Aerodynamics, John Anderson, Cambridge University Press, 1997.

Valkyrie, North American XB-70 (first and second editions), Steve Pace, Tab Books, 1984 and 1990.

Anatomy of the Aeroplane, Darrol Stinton, American Elsevier, 1996.

The Jet Makers, Charles Bright, Kansas University Press, 1978.

XB-70 Valkyrie: The Ride to Valhalla, J. Remak and J. Ventolo Jr., MBI Publishing, 1998.

Tomorrow's Storm. Frequent contributor Carl A. Posey has flown on nearly every aircraft in NOAA's fleet. He is the author of *The Living Earth Book of Wind and Weather* (Reader's Digest Association, 1994).

Scott Highton is a specialist in virtual reality photography. Check out his portfolio on the Web at www.highton.com.

The Man With the Plans. Ken Gouldthorpe is a writer living in Seattle.

Signs of Light. Michael Milstein writes beneath the clear skies of Wyoming. His last article for *Air & Space* was "Bring Me the Tail of Wild-2" (Feb./Mar. 1999).

Fire Fliers. Lance Thompson is a regular contributor to *Air & Space.* He is writing a screenplay about Claire L. Chennault, leader of the Flying Tigers.

CLASSIFIED

"UNIDENTIFIED FLYING OBJECT" OFFICIAL CONTEST RULES

1) NO PURCHASE NECESSARY

2) To enter hand print on a 3 1/2" x 5 1/2" postcard your name, address and telephone number, date of the issue cover, correctly identify the "unidentified flying object" illustrated, and be sure to follow instructions on the feature page. No mechanically reproduced entries permitted. You may enter as many times as you wish, but each entry must be mailed separately.

3) Each entry must be postmarked no later than the last day of the month on the issue cover and received by the 10th of the month following the issue date. Mail entries to: Air & Space/Smithsonian Magazine Contest, 901 D Street SW, 10th Floor, Washington DC 20024.

4) Six contests: (1) December 1998-January 1999, (2) February-March, (3) April-May, (4) June-July, (5) August-September, (6) October-November 1999 issues.

5) One winner will be randomly selected from all correctly answered entries from each of the six contests by Marden-Kane, Inc. an independent judging organization whose decision in all matters relating to the rules and administration of the contest is final and binding. Each of the six contests' winners will be awarded a Garmin 111 Handheld Satellite Navigator, approximate retail value $350.00 each.

6) SECOND CHANCE GRAND PRIZE DRAWING. In addition to the prize awards for the six contests, a "second chance" random Grand Prize drawing will take place on December 10, 1999. All eligible entries from all six contests will be automatically entered in the Grand Prize drawing. The prize...a $2,000 voucher for flight training provided by G. A. Team partner flight training facility. Winner will be provided with a list of facility locations. Transportation to and from the facility not included. Total A.R.V. of prizes $4,100.00.

7) Winners will be notified by mail. All entries become the property of Air & Space and none will be acknowledged or returned. Contest open to legal residents of the U.S. and Canada 18 years of age or older at time of entry. Void in Quebec and Puerto Rico and wherever prohibited. Employees of Smithsonian Institution, advertising and promotional agencies, contributors to Air & Space and their families not eligible. Canadian winners will be required to answer an arithmetical skill question administered by mail.

8) Odds of winning each contest dependent on the number of correct entries. Taxes, if any, are the sole responsibility of the prize winner. All Federal, State, local and provincial laws apply.

9) Sponsor not responsible for damage, losses or injury resulting from the use and acceptance of a prize. Winners consent to use of name and/or likeness for editorials, advertising and promotion purposes without further compensation, except where prohibited by law. No substitution or transfer of prize permitted.

10) For a complete winner's list, available after December 10, 1999, send a stamped, self-addressed envelope to Air & Space "Unidentified Flying Object" Contest Winners, 901 D Street SW, 10th Floor, Washington DC 20024

Sponsor: Air & Space/Smithsonian Magazine, 901 D Street SW, 10th Floor, Washington DC 20024.

CALENDAR

August 6–8
Flying Boat Festival. Sponsored by the Glenn H. Curtiss Museum. Keuka Lake, Hammondsport, NY, (607) 569-2160.

August 7
EAA Chapter 54 Fly-In and Pancake Breakfast. Lake Elmo Airport, MN, (651) 430-1200.

August 7 & September 4
EAA Chapter 690 Fly-In Pancake Breakfast. Lawrenceville, GA, (770) 339-0804.

August 15
EAA Chapter 11 Vintage Aircraft Display and Ice Cream Social. Capitol Airport, Brookfield, WI, (414) 781-8132.

August 26–29
Reunion: 368th Fighter Group, Ninth Air Force (World War II). Days Inn, Lake Shore Drive, Chicago, IL, (770) 455-8555.

September 3 & 4
Hayward Air Fair & Airshow. Hayward Airport, CA, (925) 455-2300.

September 6–12
National Stearman Fly-In. Galesburg, IL, (314) 947-7278.

September 11 & 12
FINA Dallas Airshow. Dallas Love Field, Dallas, TX, (214) 350-3600.

September 12
Pottstown Aircraft Owners and Pilots Fly-In Breakfast. Pottstown-Limerick Airport, PA, (610) 469-0107.

September 15–18
Reunion: Air Weather Reconnaissance Association. San Diego, CA, (949) 631-7607.

September 18 & 19
EAA Chapter 36 Fly-In. Potomac Airpark, Berkeley Springs, WV, (717) 294-3221.

North Central EAA Old-Fashioned Fly-In. Whiteside County Airport, Rock Falls, IL, (630) 543-6743.

September 22–25
Reunion: Air Rescue Association. San Diego, CA, (405) 672-1600.

September 23–25
Reunion: 27th Air Transport Group (World War II). Sheraton Inn Airport, Minneapolis, MN, (602) 878-7007.

September 25 & 26
Confederate Air Force Gathering of Memories Airshow and Dinner Dance. San Marcos, TX, (512) 396-1943.

FORECAST

In the Wings...

The B-2's Country Home

On the outskirts of Knob Noster, Missouri, a single-stop-sign town encircled by alfalfa farms, is Whiteman Air Force Base, home to billion-dollar B-2 Spirit stealth bombers and their sanctified culture.

Spysats-R-Us

Breaking away from its squabbling parents—the Air Force and the CIA—the post-cold-war National Reconnaissance Organization seeks a new market for satellite spy photos.

Bonus Poster: Secrets of the Sectional

Reading an aircraft navigational chart can be like cracking an encrypted Chinese spy message with only a Fruit Loops decoder ring—but not after our upcoming article and poster unlock the mystery, *sans* decoder ring, of course.

Air Safari

Seventy years of flying in and about Africa's Great Rift Valley makes for good stories over a round of Tusker beer in the Nairobi clubhouse of the Aero Club of East Africa.

ON THE WEB SITE

Examining the XB-70

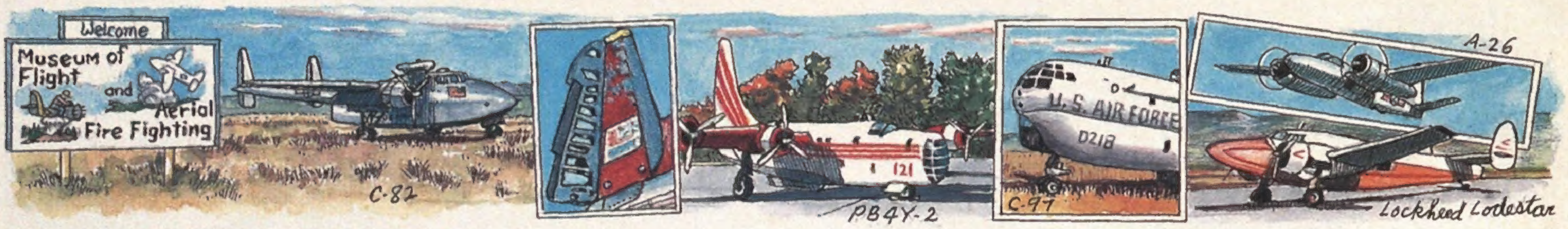
Though it looks futuristic, the XB-70 Valkyrie was the product of 1950s design. For more details about its systems, structure, and production history, visit the Web at www.airspacemag.com/ASM/mag/supp/AS99/Valkyrie.html

AF FLIGHT TEST CENTER HISTORY OFFICE

Orion Cockpit Tour

Come aboard NOAA's hurricane hunter for a 360-degree panoramic view of the cockpit, courtesy of photographer Scott Highton and QuickTime VR. Besides the view of NOAA's WP-3D Orion, you'll find panoramas of the B-2 Spirit and the Gee Bee racer at www.airspacemag.com/ASM/web/site/QTVR/menu.html

NOAA



JOHN HEINLY

Fire Fliers

Descending from Wyoming's Big Horn Mountains, Highway 20 offers few distractions as it stretches across an undulating landscape toward the distant peaks of Yellowstone National Park. But just outside the little mining town of Greybull, a tableau jolts travelers out of the interstate's monotony: an isolated rural airport whose runways are lined with World War II bombers, naval patrol aircraft, obsolete cargo haulers, and modern turboprop transports.

The improbable array is the centerpiece of the Museum of Flight and Aerial Firefighting, a collection of historic aircraft used, for the most part, to battle wildfires. The museum is situated at the South Big Horn County Airport and for the moment shares space with Hawkins & Powers Aviation, a firm that converts surplus aircraft into tankers, operates firefighting airplanes and helicopters, restores vintage warbirds, and serves as one of the museum's major benefactors.

Before the museum was established, the H&P flightline of old bombers would literally stop traffic. Vacationers driving down the highway would "pull their campers and Winnebagos right onto the ramp and drive out among the airplanes," says Duane Powers, son of H&P co-founder Gene Powers. Recognizing the appeal of the fleet, Duane and two fellow aviation enthusiasts decided to establish a museum, one that would (in addition to fencing the aircraft off from drive-by visitors) tell the story of aerial firefighting.

That story begins in 1919, when the U.S. Forest Service borrowed airplanes and pilots from the Army to serve as airborne fire spotters. It wasn't until 1936 that the service began testing the use of aircraft to actually fight fires, bombing them with containers full of water and chemical retardants. Water bombing experiments accelerated after World War II, when surplus aircraft and trained pilots became plentiful. In 1946, the forest service and the Army Air Forces modified 165-gallon auxiliary fuel tanks with stabilizing fins and proximity fuses, filled them with water, and dropped them from P-47 fighter-bombers making shallow dives. The fuses worked fine, causing the tanks to explode 50 feet above the ground, but targeting accuracy was poor. In 1953 the service demonstrated a technique that eliminated projectiles entirely: In an experiment over California, a DC-7 flying between 150 and 600 feet released water directly from an internal 2,400-gallon tank. This is essentially the method used today.

The Museum of Flight and Aerial Firefighting, South Big Horn County Airport, PO Box 412, Greybull, WY 82426. Phone (307) 765-4322; Web site: www.tctwest.net/~flight. *Open 8:00 a.m.; closing hour varies. Admission: Adults $3.00, kids $1.50.*

Government budgets for aerial firefighting have always been on the modest side, so most firefighting aircraft still come from the surplus ranks. Thus the Greybull museum's collection is also a gallery of the leftover aircraft of their day, varying in condition from fully restored and ready for action to partially disassembled and ready to serve as parts donors. Visitors to the museum first stop at the office and pick up a pamphlet that lays out a self-guided tour, from the flightline to the boneyard. There's a row of KC-97s—tanker versions of Boeing's bulbous double-deck transport, one of which currently fights wildfires in Alaska. The half-dozen distinctive twin-boom Fairchild transports (C-82 Packets and C-119 Flying Boxcars) have been retired from active tanker duty, some destined to become exhibits at other museums. Two C-118s, military versions of the DC-6, look very much like the first successful free-fall water bomber, the DC-7. The collection also includes various versions of Lockheed P-2 Neptunes and the eminently versatile C-130 Hercules, the latter equipped with custom-built 2,000-gallon variable-flow tanks.

A Lockheed L-18 Lodestar, fully restored from its flawless aluminum skin to its comfortable leather upholstery, looks as if it hasn't aged a day since it came off the Burbank, California production line half a century ago. The belligerent-looking Douglas A-26 Invader has been retired from tanker duty and now, thanks to Gene Powers, sports a split-personality paint scheme—military on one side, civilian (with a portrait of Gene's wife) on the other. And the Twin Beechcraft C-45 was never used as a tanker, but it did carry smokejumpers—firefighters who parachute into the path of a wildfire to fight it on the ground.

The most distinctive aircraft at the museum are also its hardest-working—five Consolidated PB4Y-2 Privateers. The museum displays five rare examples of this stretched, single-tail naval B-24 variant, which saw action during World War II and Korea. Fighting fires since the 1950s, the Privateers have a record of continuous service longer than that of any other aerial tanker.

The museum's collection also includes helicopters, such as the 1950s-era Kaman H-43 Huskie, which sports a pair of intermeshing rotors. Helicopters have been used in the same firefighting capacities as fixed-wing aircraft, as well as for delivering self-contained tank-pump-hose units and for stringing hoses across difficult terrain.

The museum's flightline is occasionally augmented by guest aircraft. Recently, a B-24 from the Confederate Air Force spent several months in Greybull being overhauled. The Berlin Airlift Historical Foundation is outfitting a C-97 as a flying museum, and Greybull will serve as the maintenance base for that airplane.

The appeal of the Museum of Flight and Aerial Firefighting is that many of its airplanes, even those that are pushing 60, are still on the job. Their paint is scuffed, their engines drip oil, and they bear scars that show they must regularly fly in harm's way. In short, the aviation history here is alive. No wonder so few travelers can pass it up.

—Lance Thompson

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